Technical Note N-1443

EVALUATION OF UTILITY EQUIPMENT FOR HARBOR OIL SPILL REMOVAL/RECOVERY SYSTEMS

By

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June 1976

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Port Hueneme, California 93043

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER TN-1443	2. GOVT ACCESSION NO. DN244123	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) EVALUATION OF UTILITY EQUIPMENT FOR HARBOR OIL SPILL REMOVAL/RECOVERY SYSTEMS		5. TYPE OF REPORT & PERIOD COVERED Final; Apr 1975 – Apr 1976 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Suresh C. Garg		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS CIVIL ENGINEERING LABORATORY Naval Construction Battalion Center Port Hueneme, California 93043		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 63721N; Y41-21-001-01-001
11. CONTROLLING OFFICE NAME AND ADDRESS Naval Facilities Engineering Command Alexandria, Virginia 22332		12. REPORT DATE June 1976 13. NUMBER OF PAGES 112
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Oil spills, harbors, oil recovery, oil containment booms, utility boats, flattop boats, mooring systems.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The following items of equipment for harbor oil spill cleanup operations were evaluated: a power assistance unit for deploying and retrieving boom, a 20-foot utility boat, a 28-foot flattop boat, three boom mooring systems, a dust abatement attachment for a sorbent distributor, and the associated connectors, shackles, and lines. A description of the test program, the test results, and recommendations for

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Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

20. Continued

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EVALUATION OF UTILITY EQUIPMENT FOR HARBOR OIL SPILL REMOVAL/RECOVERY SYSTEMS (Final), by Suresh C. Garg
TN-1443 112 pp illus June 1976 Unclassified

1. Oil spills 2. Recovery systems I. Y41-21-001-01-001

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INTRODUCTION

"Utility equipment", as used in this report, refers to utility boats, flattop boats, mooring systems, sorbent dispensing systems, power assistance units for boom deployment and retrieval, and various types of connectors, shackles, and lines required during the cleanup of an oil spill in harbor areas. For a successful cleanup of an oil spill, the utility equipment must be compatible with itself and with the booms and skimmers. In addition, systematic procedures must be used for the deployment and retrieval of all oil spill cleanup equipment, including the utility equipment. The purpose of this evaluation was to develop procedures for deployment and retrieval of the various items of equipment, to suggest improvements in designs where desirable, to point out precautions that should be observed in their use during an actual oil spill removal operation, and to estimate manpower requirements for operation of the utility equipment.

A preliminary draft of the proposed test program for the utility equipment was forwarded to the Naval Facilities Engineering Command (NAVFAC) via reference 1 for their comments and approval. NAVFAC comments, reference 2, were incorporated in the revised plan, reference 3. The descriptions of the utility boats and the flattop boat which were purchased for evaluation by the Civil Engineering Laboratory (CEL) were forwarded to NAVFAC via reference 4.

NAVFAC completed some of the tests described in reference 3 through a contract with the Naval Weapons Engineering Support Activity (NAVWESA), as noted in reference 5, which necessitated a reduction in scope of CEL's test plans to eliminate duplication of effort. The final revision, reference 6, included additional NAVFAC comments received via reference 7.

The detailed plan for the test program, which was conducted in Port Hueneme harbor is presented in Appendix A. This report describes the test program, the results of the tests completed during this evaluation, and the procedures used for deployment and retrieval of various items of equipment. Deficiencies in equipment, when observed, have also been pointed out in this report. This report complements the observations and recommendations reported in reference 8. Disagreements in recommendations of reference 8 and those developed during this test program have been pointed out.

BACKGROUND

CEL has been evaluating oil spill cleanup equipment under the Harbor Oil Spill Removal/Recovery Systems Program. During Phase I of this program, completed in FY-73, detailed information was obtained from manufacturers of equipment for the containment, removal, storage and transfer, and separation functions. The selected items of equipment were then subjected to a test and evaluation program to determine the best equipment for each function.

Operational and logistic improvements for the equipment being furnished to Naval activities by NAVFAC were addressed during Phase II. During Phase III, currently in progress, oil containment booms and skimmers which have become available since the conclusion of the Phase I have been analytically evaluated. Based on this evaluation, one containment boom and three skimmers have been selected for testing. Tests of selected utility equipment are reported in this Technical Note.

DISCUSSION

General Comments

Equipment

NAVWESA completed a number of tests, reference 8, which were included in CEL's proposed test program of January 1975, reference 3. These tests were, therefore, deleted from the revised test program, reference 6. In view of these revisions, the test program carried out by CEL complemented work reported in reference 8.

The utility boats (UTB), the flattop boat (FTB), and the 75 and 85 hp outboard engines for these boats were purchased prior to the availability of reference 8 test data. Therefore, information on the effectiveness of various outboard engines was not available to assist CEL in selecting the best possible outboard engines for this evaluation. A 5,000-lb and a 10,000-lb mooring system were purchased by CEL. Two 2,000-lb mooring systems were made available to CEL by NAVFAC. The power assistance unit (PAU) used in these tests was developed by Murphy Pacific Marine Salvage Company for CEL under contract, and modified by CEL to enhance performance. Because the test plan did not include evaluation of booms, 300-ft lengths of three different booms, 48-inch Kepner Sea Curtain, 36-inch Bennett Inshore Oil Boom, and 36-inch Bennett Class III U.S. Navy Boom (BM-74-U.S.-030-01), purchased by CEL earlier, were considered to be adequate for this evaluation. For the Kepner Sea Curtain boom, flotation is provided by enclosed cylindrical logs. For the Bennett Inshore Oil Boom, flotation is provided by enclosed rectangular logs. However, for the Bennett Class III U.S. Navy Boom, flotation is provided by semi-cylindrical logs attached to both sides of the boom by plastic straps.

Procedures

Early in the evaluation it became evident that time and manpower required to complete any element of the utility equipment test program depended largely upon (i) the physical strength of each member of the crew, (ii) the exposure and training of the crew in handling equipment and their familiarity with the procedures, (iii) the motivation of the

crew, (iv) the rapport among team crew members, (v) communication equipment available, (vi) the climatic conditions (rain, temperature, winds), and (vii) harbor conditions (waves, currents, tide). Each of these factors was felt to be important enough to cause up to a two- to three-fold variation in time required to complete any task.

In view of the many variables listed above, and the necessity of prior coordination with other departments on a Navy base to ensure timely availability of a ramp, a crane, fuel, and tools and other equipment, it was decided not to attempt to "beat the clock" in tests in which a stopwatch was used to determine the time required to complete a task. The crew was allowed to work at its normal pace, and additional help was made available whenever the crew felt it needed more men to complete a task. This approach was felt to be appropriate to simulate normal manpower behavior on a Navy base.

Additionally, it must be kept in mind that all tests were performed under near-perfect weather conditions of the Port Hueneme harbor. On most test days, there were hardly any winds or waves, and all tests were conducted under bright sunshine conditions. In real life, first, the weather is usually not so obliging and, second, oil spills are likely to occur more often when the weather is adverse. Therefore, the time required to perform a task may take several times longer than the time reported here for the same task.

Although accuracy of all measurements of time was ± 0.2 second, therefore allowing data to be given in fractions of a minute, the usefulness of such accuracy in evaluating utility equipment is very limited in view of the numerous uncontrollable variables discussed above. For the same reason, no attempt was made to determine the absolute minimum number of people required to complete a task. For instance, six people were used for boom deployment from the FTB. It is possible to complete this task with fewer people, as in reference 8, but it would take a longer period of time.

In view of the above variables, the utility equipment evaluation involved subjective decisions on manpower and time required to perform a task. All of the factors mentioned earlier will affect manpower required to complete a task, time required to complete a task, or both.

This report is divided into several sections, according to the equipment under evaluation. However, both UTBs and the FTB were used in most tests and, therefore, observations and comments on the UTBs and the FTB are based upon their performance during the tests in which they were used.

Evaluation of the Power Assistance Unit

Modifications

The PAU developed by Murphy Pacific Marine and Salvage Company under a CEL contract was felt to be deficient in two ways: (1) the

low pressure tires may not retain the boom during deployment and retrieval, and (2) the PAU may not prevent the pilings, camel log, or other projections on a pier from scraping the boom. To overcome these difficulties, two modifications of the PAU were carried out. First, a vertical, boom retaining channel member was bolted on each side of the low pressure tire assembly and a horizontal boom retaining channel member was welded to the upper edges of the two vertical boom retaining members, Figure 1. This modification ensured that the boom would be retained on the low pressure tires under all circumstances. Second, a chute was bolted to the PAU to protect the boom from the pilings. These modifications are shown in Figures 2, 3, and 4. The design drawing of the entire PAU modification is shown in Figure 5.

The chute of the PAU is such that it can be assembled during use and removed from the main PAU unit during storage. The chute design was based upon the stipulation that the PAU should be firmly located on the pier; therefore, to clear protrusions on the pier, the chute must hang over the edge of the pier. However, an examination of the pilings showed that to clear the pilings and the camel log, the chute attached to the PAU would have to be very large, which would make the PAU unstable. To overcome this difficulty, a smaller chute was fabricated and the PAU was rigidly fixed to the pilings, as shown in Figures 3 and 4.

Operation

There were three difficulties noted in the PAU operation. First, the foot control, Figure 6, requires that it be pressed to stop the tires in an emergency. A more reasonable, and safer design would require that it be kept pressed during rotation of the tires. In the safer design, any emergency or operator distraction will cause the operator to step off the control thereby automatically stopping the tires from rotation. Second, there is no neutral gear to permit the tires to rotate freely during deployment of the boom. Therefore, physical removal of the drive chain was necessary for each boom deployment operation. This procedure is cumbersome, time consuming, and there is an ever present danger of losing the small chain parts during their installation and removal procedures. It is, therefore, recommended that the PAU be modified to permit free rotation of the tires to assist deployment of boom. Third, during operation of the PAU, the boom and the line from the boom kept getting stuck between the tires. This problem could be solved if the four tires are replaced by a long rubber coated cylinder.

During deployment and retrieval of boom using the PAU, it was found necessary to have a flat, nonskid surface around the PAU as a walkway for the crew because the PAU was not resting on the pier. During tests, this surface consisted of a 4' x 8' x 3/4" plywood sheet. It was felt that a surface of this type could be useful on all types of pier surfaces.

Deployment and Retrieval of the Boom

300-ft sections of Sea Curtain and the two Bennett booms were connected together using standard Navy boom connectors, and the mixed 900-ft boom was deployed and retrieved using the PAU. Two types of deployment and retrieval procedures were carried out: (1) deployment from the pier into the water, and (2) deployment from the pier onto the FTB. Procedures, manpower, and time required to deploy boom from the pier to the FTB are given later under Evaluation of the Flattop Boat. In this section, only deployment of boom from the pier into water is described.

Deployment: Prior to deployment, the 900-ft boom was faked crosswise on the pier, Figure 7. A boom towing attachment was attached to one end of the boom, a 50-ft towing line was connected to the towing attachment, and the free end of the line was dropped through the PAU to the crew in the UTB. The boom was deployed over the PAU as the UTB slowly pulled the boom into the water, and kept the boom straight ahead of the PAU, Figure 8. Several precautionary measures were taken during deployment. (1) the UTB kept the boom in line with the PAU at all times by maneuvering as required. (2) One operator at the PAU kept the boom centered on the tires at all times. (3) A minimum crew of two was used in all UTBs.

The deployment required a total of six men: two men in a UTB, one man at the PAU to keep the boom centered on the tires, and three men paying the boom over the PAU into the water. The deployment of the 900-ft mixed boom took 8.67 minutes, under no wind, and no wave conditions.

Retrieval: For boom retrieval, the towing line at one end of the boom was thrown to the crew on the pier. The towing line was then passed through the PAU. There was a mild wind (about 5 knots) which made it necessary to use two UTBs to keep the boom straight and in line with the PAU. One UTB held the towing line at the other end of the boom whereas the second UTB was used to pull the boom in the middle, on occasions, to line it up with the PAU. However, care was taken to ensure that the UTB holding one end of the boom did not exert a pull on the boom, and against the crew pulling the boom on the pier. It was felt that in stronger winds, it will not be possible to pull the boom out of water using the PAU because the winds will push the boom in one direction. Then, to keep the boom in line with the PAU, one would need a boat pulling the loose end of the boom to line up with the PAU. If so, it will be extremely difficult for the crew on the pier to retrieve boom when the UTB is working against them. In strong winds, the most effective means for retrieving boom could be a crane.

To reduce crew fatigue, it was necessary to use six, strong, young, experienced, and motivated men to pull the boom out of the water under the mild wind conditions of 5 knots: one man on the camel log to line up the boom with the PAU, one man on the emergency PAU

controls and also assisting in lining up the boom on the tires, and four men on the pier pulling the boom and faking it on the pier. An additional two men were required in each of the two UTBs. The retrieval of the 900-ft boom was completed in 15.05 minutes.

Another modification of the PAU to simplify these procedures would be to place the PAU on a turntable so that it can rotate in the horizontal plane to line up with the boom. This will eliminate the need for the second UTB and one man on the camel log, and reduce the retrieval time. An alternative to these procedures is to use a crane to pull the boom out of the water and lay it on the pier. If a crane is available, this procedure should be the easiest, especially under adverse weather conditions.

Another more effective alternative for retrieving boom than using men to pull the boom through the PAU, is to attach the towing line to a forklift truck or van and have the forklift truck or van pull the boom through the PAU.

To assist the crew in boom deployment and retrieval, the Navy boom design should include strong handles every 6-8 ft for holding purposes. There is no practical way to prevent boom from being dragged on the pier during the deployment and retrieval procedures. However, care should be taken that the pier area used for boom faking and storage is relatively clean and smooth. Covering the area with a strong plastic sheet would reduce the abrasion on the boom while it is being dragged on the pier.

Observations, Comments, and Suggestions

The following is a brief summary of all suggested changes in the PAU and precautions that must be observed during its use.

1. The foot tire control mechanism should be rewired to require an operator to keep it pressed for tire rotation.

2. The PAU drive mechanism should be modified to allow free rotation of the tire during boom deployment without the necessity of removing the drive chain.

3. The boom retaining modification shown in Figures 1-5 should be attached on all PAUs to ensure that the boom remains on the tires during deployment and retrieval. However, the channel-iron used in this modification should be replaced by pipes to minimize the number of sharp edges.

4. The chute should be attached to all PAUs to reduce the risk of boom damage from pilings and protrusions on the pier. However, the angle irons used in the modification should be replaced by smooth pipes to minimize damage to the booms.

5. The PAU should be rigidly fixed to the pier and/or pilings to ensure that it does not topple over into the water during use.

6. A flat, nonskid walking surface should be provided around the PAU for operator safety.

7. The PAU should be located on the pier or the pilings in such a way as to ensure that the chute clears all protrusions on the pier's edge.

8. The four-tire assembly of the PAU should be replaced by a single, rubber coated cylinder to minimize entrapment of the tow line, boom tension line, or small boom protrusions between the tires.

9. The selection of a pier should be such as to minimize abrasion of the boom when it is dragged on the pier during deployment and retrieval. The location of the PAU on the pier should be such that it permits a UTB to pull the entire length of boom over and in line with the PAU.

10. If possible, the entire PAU assembly should be placed on a stable turntable so that it could rotate freely and always face the direction of the boom during deployment and retrieval, thereby minimizing the necessity of maneuvers by the UTB to keep the boom in line with the PAU.

Evaluation of the Utility Boat

Description and Modifications

The 20-ft UTBs used in the test program were purchased from Lanness K. McKee & Co., Inc., P. O. Box 207, Fairmont, North Carolina 28340. The purchase description prepared by NAVFAC for their procurement of UTBs is presented in Appendix B. CEL used the same purchase description with the following exceptions:

a. In lieu of the Mercury engine, CEL provided an 85 hp Johnson outboard engine with a 14-inch diameter, 15-inch pitch propeller.

b. CEL did not procure the trailer.

c. CEL did not procure the U.S. Coast Guard approved safety equipment.

d. The floor of the interior was not equipped with a nonskid surface.

To ensure that there was sufficient fuel onboard for testing over a 4-hour period, three 6-gal dual fuel tanks were secured in each UTB. Accessories purchased with the UTB were:

- stainless steel bow rail
- stainless steel side rails
- side-mounted console
- fiberglass swivel seat, cover, and aluminum pedestal
- plexiglass windshield
- rack and pinion mechanical steering
- special bow and stern eyes
- additional layers of 24-oz woven roving in hull
- 14-oz heavy duty mooring covers
- 35,000 candle power search light
- compressed air fog horn
- stainless steel deck cleats and lights
- plastic battery box

Samson Post: As recommended in reference 8, a samson post was installed in each of the two UTBs for towing, Figure 9. Straight line and catenary tows of boom were carried out using the UTBs with the tow line tied to the samson post, and also with the tow lines tied to the transom, to determine differences in maneuverability of the UTB. These tests confirmed findings of reference 8 that the maneuverability of the UTB was noticeably better when the tow line was attached to the samson post. However, the tests indicated two problem areas: (1) the height of the CEL designed post was such that when the boom was pulled on one side of the UTB, the tension in the line caused a sufficiently large turning moment to cause the boat to become unstable, and (2) the outboard engine was in the way of the tow line on occasions. A possible reason for the first problem was that the post was too high. A simple modification of the load carrying members of the samson post minimized both of the above possible problems. The modification consisted of installing a fairlead on the load carrying members of the samson post near the transom, Figure 10, high enough to clear the motor when it is raised to the stored position. The tow line from the samson post was then connected to the boom through the fairlead. This modification provided two benefits: (1) it lowered the effective tow point, and (2) the line was no longer in danger of hitting the engine.

In the subsequent test program, the samson post-fairlead arrangement was used exclusively for towing purposes. The design drawing of the complete modification, as used in this test program, is given in Figure 11. These modifications added stability to the UTB and provided much better maneuverability.

It was felt, however, that the maneuverability and the stability of the UTB could be further enhanced if the samson tow point were lowered, the fairlead removed, and a guardrail installed as near the engine as possible to prevent the line from hitting the engine. The guardrail could only be lowered if it is moved further towards the engine so that it clears the engine completely. It is, therefore, recommended that a new design incorporating all these changes followed by test and evaluation of the effectiveness of the new design should be carried out. A conceptual illustration of the revised samson post-guardrail modification of the UTB is given in Figure 12.

Fenders: The UTBs did not come with fenders to protect the boat structure from hitting the pilings and other objects and crafts. Two fenders, 5-1/2-inch diameter and 20-inch long on the port and the starboard sides of each boat were found to be useful in protecting the boat. It is, therefore, recommended that fenders be used on the UTBs during harbor oil spill removal/recovery operations. An alternative to fenders is to install permanent bumpers as recommended in reference 8.

Speedometers and tachometers: A speedometer was used on each boat for speed measurements during this evaluation. However, various attempts failed to provide a steady state reading on the speedometers. Therefore, speedometers were considered unsuitable for accurate measurements. In this test program, all measurements were made over measured distances outside the Port Hueneme harbor. The measured distances used were 0.367 and 1.0 nautical miles.

Except for the purposes of measuring speeds during test and evaluation, it was felt that speedometers and tachometers will be of little use in actual oil spill situations and, therefore, they are not recommended.

Nonskid deck: Although no effort was made to provide a nonskid deck on the UTBs because the test program did not call for spilling any oil, treatment of the deck to produce a nonskid surface was felt to be essential in harbor oil spill cleanup operations. Evaluation of various methods of providing a nonskid surface was completed earlier, reference 8, and therefore, not duplicated in this test program.

Towing lines: The towing lines purchased for the test program were 3/4-inch diameter, polyester cover, polypropylene core, 2-in-1 stable braid, with a thimble at one end. Mooring lines for the UTBs were 0.5-inch diameter nylon. Because the towing lines were not 100 percent polypropylene, they did not float. It is, therefore, recommended that all towing lines be 100 percent polypropylene, so that it is easier to pick them up during deployment and retrieval.

Test and Evaluation

Fuel Capacity: To determine the fuel consumption rate at maximum engine throttle, and therefore the operational capacity of a 6-gal fuel tank, two test runs were made, one with no load and the other while pulling the 900-ft boom. The time required to consume 6 gallons of fuel was measured.

In the straight run at maximum throttle with no load, 6 gallons of fuel lasted 39.2 minutes. However, when the same test was repeated while towing the 900-ft boom, 6 gallons of fuel lasted 49.75 minutes.

In most oil spill removal situations, there would be no need to run the engines at full throttle, and, therefore, the fuel tank will last much longer than the above measured times. However, to ensure that

the oil spill removal operation is not interrupted due to a shortage of fuel aboard the UTB, it is recommended that the UTB carry three, 6-gal fuel tanks.

As a precautionary measure, the outboard engines should never be run at maximum throttle since the useful life of the engine is drastically reduced at the maximum throttle. One of the UTB engines burned out just prior to the end of the test program.

Deployment: The UTB was deployed by a crane. A line was attached to the pad eyes near the bow and the transom. No special precautions were taken, and the complete deployment of the boat was completed in 2.5 minutes in good weather (no winds or waves). Four men were required to complete deployment: one crane operator, one man on the pier to watch the boat, and two men on the camel log to protect the boat from hitting the pilings and to secure the boat after deployment. The crane was in position on the pier prior to start of the measurement.

Retrieval: The retrieval was also carried out with a crane, and the total time required to connect lines to the UTB, lift the UTB out of water and place it on the pier, and remove the lines took 3 minutes. Four men were required to complete retrieval: two men from the UTB positioned on the camel log to protect the UTB from hitting the pilings, one man on the pier to guide the UTB, and one crane operator.

Straight line tow: The 900-ft mixed boom was towed in a straight line by tying the towing line to the samson post through the fairlead installed on the load-carrying members of the samson post. During towing, the line kept rubbing against the fairlead and soon began to wear off. To extend the useful life of the tow line, it is recommended that the fairlead, if used, should have a roller in it. Alternatively, the contact point on the line at the fairlead/guardrail should be changed frequently to maintain uniform wear on the line.

The boom was towed approximately 50 ft behind the boat's transom under test conditions of negligible winds, currents, and waves. With three men in the UTB, weighing approximately 500 lbs, and maximum throttle on the engine, a distance of one nautical mile was completed in 16.04 minutes travelling north and in 15.85 minutes travelling south. The average speed of the boat was therefore approximately 3.76 knots.

One observation made during paying from and pulling the line into the UTB was that if a reel were attached to the samson post to store the tow line, the risk of entanglement would be minimized.

Catenary tow: The towing capacity of two UTBs was determined by towing the 900-ft boom in a catenary with an opening of approximately 65 percent. The first attempt was made under 10-knot winds. During towing from the samson post, with engines at full throttle, the transom was noticed to submerge enough to cause flooding of the UTB. The test was discontinued and deferred for more favorable weather. Also, it was

decided to conduct this test while pulling from the transom instead of the samson post.

The second towing attempt was carried out from the transom using a bridle assembly. The winds were light and variable, waves were less than 6 inches, and the ground swell was of the order of 1 ft.

For the test, the tow line had a shackle connected to a Newco thimble in the bridle, which permitted the bridle to slide freely. This arrangement prevented the transom submergence at maximum throttle. However, several problems were noted.

a. The bridle kept hitting the engine during turning.

b. The turning radius of the UTB was larger compared to towing from the samson post.

c. The maneuverability of the UTB was greatly reduced.

It was felt that towing from the samson post would be much better, and further improvements could be obtained if:

a. The height of the post were reduced,

b. The fairlead were replaced by a guardrail located near the engine, as shown in Figure 12.

c. The height of the transom were increased and engines with extra long shafts were used.

During the entire catenary tow, both engines were maintained at full throttle, a distance between the two UTBs of approximately 600 ft was maintained, and each UTB was towing one end of the 900-ft boom approximately 50 ft behind its transom, as compared to 150 ft recommended in reference 8. The distance of 600 ft between the two UTBs was maintained only visually, as no accurate measurement was felt feasible.

The test run was made over a measured distance of 0.367 nautical miles. Two tests were carried out while travelling north and two tests were carried out while travelling south. The north test runs took 25.41 minutes and 24.11 minutes, for an average of 24.76 minutes. The south test runs took 16.25 minutes and 15.90 minutes, for an average of 16.08 minutes. Therefore, the average time required to complete the test was calculated to be 20.42 minutes for negligible currents and winds, yielding a maximum speed of 1.08 knots.

Towing oil storage bag: Towing tests were conducted on the Kepner Sea Container flexible oil storage bag. The bag is fabricated from vinyl-coated nylon, has a nominal capacity of 2500 gal, and has a dry weight of 240 lb. When full, the bag is 30 ft long, 5 ft wide, and 4.5 ft high. The bag was towed behind the transom from the samson post. The boat maneuvered well during this tow, with the bag both fishtailing as well as porpoising.

Ease of connecting/disconnecting boom sections: The ease with which sections of boom could be connected and disconnected was determined by measuring time and manpower required to complete the operation. Once the boom joint was picked up by the crew in the UTB, it took two men, less than 15 seconds to completely disconnect the joint. Similarly, once the two sections of the boom were in the hands of the crew, it took two men, less than 15 seconds to complete the connection. In both of these operations, a third man was required on the controls of the UTB. Disconnecting the boom sections required a pair of pliers and adjustable vice grips.

It was noted during these tests that the UTB became unstable when waves generated from passing tugboats struck the UTB broadside. To minimize this instability, the UTB operator must be on constant alert for waves generated from tugboats so that he can orient the UTB normal to the oncoming waves. During tests in the harbor, the UTB was observed to be unstable on days when there were mild wind and wave conditions.

The UTBs therefore appear to be somewhat inadequate as far as stability is concerned. Similarly, the power of the engine appears inadequate for holding the boom in a catenary configuration if the current exceeds 1 knot.

Several CEL riggers participated in the Navy-assisted cleanup operation of the Santa Barbara crude oil spill in January 1969. They observed that most of the boats with outboard engines were down because the outboard cooling systems of these engines had become clogged by the oil-soaked debris usually found in harbor and beach areas. If these boats were powered by engines with closed cooling systems, the boats would have stayed operational regardless of the debris. During the CEL tests, the outboard engines of the UTBs stopped on two occasions because the propellers became clogged with debris from the harbor water. For trouble-free operation of UTBs during oil cleanup operations, it is recommended that outboard engines with outboard cooling systems be replaced by engines with closed cooling systems.

Observations, Comments, and Suggestions

The following is a brief summary of all observations, suggested changes in the UTBs, and precautions that must be observed during their use.

1. A standard samson post-guardrail design should be developed and it should be incorporated in all present UTBs and all future UTB procurements.

2. Two fenders on both the port and the starboard sides of the UTB should be used to protect the UTB. Alternatively, bumpers recommended in reference 8 should be used.

3. Speedometers and/or tachometers are not necessary on the UTBs, and their use is not recommended.

4. The deck of the UTB should be treated to produce nonskid surfaces.

5. All lines should be made from 100 percent polypropylene to reduce the effort required in picking them up during the deployment and retrieval procedures.

6. A set of three 6-gal fuel tanks should be provided on each UTB to minimize disruptions of the oil removal operations due to shortage of fuel.

7. To maximize useful life of the outboard engines, they should not be run continuously at full throttle.

8. The deployment and retrieval of the UTB with a crane is easy, fast, and safe. It is therefore, recommended that a crane be used in all deployments and retrievals of the UTB.

9. All towing should be conducted from the samson post to enhance stability and maneuverability of the UTB.

10. A towing line length of 50 ft appears adequate. A reel should be provided at the samson post for storage of the towing line and to prevent entanglement.

11. The UTB could be used to tow a full oil storage bag from the oil spill site to the pier, to connect and disconnect boom sections, and to tow a flattop boat.

12. The UTB appears to lack stability and power for cleanup operations under less than perfect weather conditions. Extreme caution is required even under near perfect weather conditions.

13. The 2,000-lb mooring system evaluated in this test program could be safely deployed and retrieved from the UTB under calm weather conditions. However, the 5,000-lb and 10,000-lb mooring systems could not be safely deployed and retrieved. See the section "Evaluation of Mooring Systems" for further details.

14. If possible, the outboard engines with outboard cooling systems should be replaced by engines with closed cooling systems to ensure trouble-free operations in harbor oil spill removal operations.

Evaluation of the Flattop Boat

Description and Assembly

The FTB used in this evaluation was purchased from Slickbar, Inc., P.O. Box 139, Southport, Connecticut 06490. The FTB is a tri-hulled vessel of 14.7-ft beam and 27.5-ft overall length. The boat is foldable, and a trailer, for ease in transportation, may be ordered as an extra. Construction drawings giving dimensions and material of construction are not included in this report because Slickbar refused to supply them to CEL for proprietary reasons. However, the following information was available from Slickbar:

- length - 27.5 ft
- beam - 14.7 ft
- height of outer rails - 3.5 ft
- height of inner rails - 2.5 ft

Detailed instructions with photographs showing the procedures for folding the FTB prior to deployment were supplied by the manufacturer, and they are included in Appendix C. Appendix C also includes deployment and retrieval procedures, folding procedures, and maintenance requirements. Various precautions that must be observed during folding, unfolding, deployment, and retrieval are also included in Appendix C. These precautions were observed during the execution of this test program.

The outboard engines selected to power the FTB were two, 75 hp, Johnson high performance engines with 13 1/4-inch diameter, 17-inch pitch propellers.

Deployment of the Flattop Boat

The manufacturer of the FTB recommends that the boat be deployed over a ramp. Attempts were made to design a lifting sling which could be used to deploy the FTB using a crane. Based upon the weight of the FTB (5240 $\pm$ 20 lbs) and the unavailability of safe locations on the FTB to secure lifting lines or to place lifting bars, the designers felt that the folding FTB should not be lifted with a crane. To ensure that we did not damage the boat, no attempt was made to rig up "something" just to see if the cleats, railings, etc., could be used to lift the FTB for deployment.

If a Navy base does not have a suitable ramp, or if the ramp may not be available for the FTB deployment and retrieval, then it is recommended that the rigid FTB be purchased instead of the folding FTB for the intended use.

The deployment of the FTB was, therefore, carried out over a ramp which could be raised or lowered. To accomplish this, the bow of the

boat trailer was first secured to a vehicle (a pickup truck capable of handling 7500-lb loads). The vehicle was then used to slowly back up the trailer carrying the FTB onto the ramp. Care was exercised to ensure that (1) the trailer and the vehicle were centered on the ramp, and (2) neither the trailer nor the vehicle touched the side railings of the ramp. The vehicle was backed slowly until the wheels of the trailer reached the edge of the ramp, Figure 13. The vehicle was then secured in place first with its brakes, and then by a line to the ramp railings to ensure that the entire assembly did not slide into the water when the ramp was lowered.

Next, the ramp was lowered until the water reached the waterline of the FTB at the stern. The outboard engines were then lowered into water and the engines were started, Figure 14. The boat was then backed away from the ramp with the assistance of the propellers.

An experienced crew of four men was required to complete deployment: a driver, a ramp control operator, and two people observing and instructing the driver to ensure alignment of the FTB with the ramp. Later, one person was required on the ramp control, one person was required at the FTB controls, and two people were required for lining up the FTB and providing assistance when necessary to push the boat off the trailer and into the water.

Using a crew of four trained people, the deployment of the FTB from a ramp was completed in 10.0 minutes. The time was recorded from the time the vehicle started lining up with the ramp prior to backing up to the time when the FTB left the trailer.

Retrieval of the Flattop Boat

The procedure for retrieval of the FTB was the reverse of the deployment procedure, with only minor differences. Only the differences are described here. For retrieval, the FTB was maneuvered using its propellers so that the FTB was lined up with the trailer on the ramp. The FTB was then run up on the trailer by the use of the FTB propellers as far as it could go. The winch line from the trailer was then attached to the towing eye on the center hull, and the FTB was pulled out of the water manually.

Four men were required to complete the retrieval: one man on the ramp control, one man on the FTB controls, one man pulling the boat with the winch, and the fourth man in the vehicle. The total time required for retrieval of the FTB was 13.0 minutes.

Loading the Flattop Boat with Boom

(i) Maximum loading: To complete loading the FTB from a pier, the FTB was maneuvered so that the bow was parallel to and facing the camel log. The boat was pulled close to the camel log as far as possible and then

secured to the pilings with 3/4-inch-diameter, nylon mooring lines. The towing attachment was passed through the PAU and handed to people on the FTB. For boom deployment, the drive chain of the PAU was physically removed so that the tires would rotate freely and assist in boom deployment.

Four men were required on the FTB boat to pull the boom and fake it down on the deck. The faking was carried out in two different ways: fore and aft, and athwartship. An additional three men were required on the pier: one man to maintain the boom's smooth travel over the PAU and two men to bring the boom from the pier (or boom box, if used) to the PAU.

The total capacity of the FTB was found to be the 900-ft of boom used in these tests and five man, with an average weight of 160 lb. The weights of the 300-ft (approximate) sections of each of the three booms, 48-inch Kepner Sea Curtain, 36-inch Bennett Inland Oil Boom, and 36-inch Bennett Class III U.S. Navy Boom, were 1450 lb, 1010 lb, and 1090 lb, respectively. The accuracy of each weight is ± 10 lb. With this total load of 4350 lb (800 + 1450 + 1010 + 1090), the water level was at or slightly below the FTB's waterline, Figure 15. Similarly, as in Figure 15, the entire usable area of the deck of the FTB was completely covered with multiple layers of the boom of 900 ft total length. There was no space left on the deck to permit the crew to cross the boat athwartship. It is felt that the folding FTB should not be loaded any more than the load attempted in these tests. The total usable deck area of the FTB between inner rails is approximately 9'-8" x 23'-7", or 228 ft^2. The total deck length, 23'-7", must be reduced by the space required by the crew to cross athwartship.

Under negligible winds and waves, the time required for complete loading of the FTB with 900 ft of boom, faked on the pier at the start, was 9.9 minutes.

(ii) Partial Loading: If the total length of boom required to contain a spill is less than 900 ft, then there may be some space on the deck which could be used for other purposes. Because the Navy has been procuring the 36-inch Bennett Class III U.S. Navy Boom, the 300-ft length of this boom was loaded athwartship on the FTB in as compact a form as appeared practical and safe, and the free deck space was measured. The length of the free deck space was 11'-6"; i.e., 300 ft of Navy boom occupied approximately 49% of the maximum available space, before making any allowance for walk paths. An upper limit of the FTB for carrying the Navy's 36-inch boom may therefore be assumed to be about 500 ft, if a 2-ft wide walkway is allowed on both the bow and the stern.

The usable width of the FTB between inner rails of 9'-8" is not a whole multiple of the length of each float of the Navy boom presently being procured. Therefore, for the most effective use of the deck space, it is necessary that the specifications of the FTB and the Navy boom be modified to ensure that the usable width of the FTB will be slightly in excess of an integral multiple of the length of the boom floats. As shown later in this chapter, faking the boom fore to aft on this FTB is not recommended for safety considerations.

Maximum Speed of the Flattop Boat Under Own Power

(i) Carrying the maximum load: The FTB loaded with the 900-ft boom and five men, a total estimated load of 4350 lb, was run on a straight, measured distance of one nautical mile on its own power at maximum throttle on both engines. To minimize errors in measurement due to currents and winds, each north test run was immediately followed by a south test run, and the mean time was taken to be representative of the actual time the FTB would have required in the absence of winds and currents.

These tests were carried out under calm conditions with negligible winds and waves. The FTB was found to be stable and buoyant during the test. The time to travel one nautical mile northward was 3.83 minutes, and the time to travel the same distance southward was 3.63 minutes. The average time was, therefore, 3.73 minutes, yielding a maximum speed of the FTB of approximately 16 knots.

(ii) Carrying a partial load: The partial load selected for this test consisted of 300 ft each of the two Bennett booms, and three men, for a total load of approximately 2600 lb. The winds were negligible but waves were approximately 1-ft high. The time to travel one nautical mile northward was 3.53 minutes whereas the time required to travel the same distance southward was 3.27 minutes. The average time was, therefore, 3.4 minutes, yielding a maximum speed of approximately 17.6 knots.

(iii) Carrying negligible loads: The last series of test runs under the FTB's own power was conducted with no boom on deck but with five people on board (approximate weight: 800 lb). Under negligible winds and waves, the time required to travel one nautical mile northward was 2.77 minutes, and for the same distance southward it was 2.75 minutes. The average time of 2.76 minutes yielded a maximum speed of approximately 21.7 knots. These results are plotted in Figure 16 for comparison.

Maximum Speed when Towed by a Utility Boat

To complete these tests, the FTB was towed astern by a UTB, as recommended in reference 8, with maximum throttle on the UTB's 85 hp engine. The towing line of the UTB was tied to the samson post at one end, through the fairlead, and then to the pad-eye on the center hull of the FTB. A distance between the transom of the UTB and the bow of the FTB of approximately 50 ft was maintained in these tests. A total of three different loading levels on the FTB were tested over a measured distance of one nautical mile, both going north and going south. In each test, a crew of three people was used in the UTB.

(i) Flattop boat fully loaded: For these tests, the FTB was loaded with 900 ft of boom and five men, with a total load of 4350 lb. Two positions of the FTB propeller were tested to determine the difference in speeds, if any. For the first test, the propellers were pulled up

in the normal position for storage, whereas in the second test they were left in the water. The times required to complete the one nautical mile speed runs are listed in the table below.

Propellers	Time to Complete Northward Runs, Minutes	Time to Complete Southward Runs, Minutes	Winds	Waves
In water	9.60	8.58	Neg.*	Neg.
Out of water	9.67	8.57	Neg.	Neg.
Average time in the four tests: 9.11 min Maximum towing speed under zero current and wind conditions: 6.6 knots				

*Negligible

It may be seen from the table that the position of the propellers had no noticeable effect upon the total drag created by the FTB. The presence of current in the test area may also be noted from the difference in time required to complete the test runs northwards and southwards. From these measurements, the calculated value of the current's northward component was approximately 1/4 knot.

(ii) Flattop boat partially loaded: Based upon the observation that the position of the propellers did not affect the measurements, the propellers were kept in the stored position in all subsequent tests in this series. The partial FTB loading consisted of 300 ft each of both Bennett booms and three men, totaling 2600 lb. There was no noticeable wind but waves were estimated to be as high as 1 ft.

The time required to complete the maximum speed run was 9.63 minutes going north and 8.45 minutes going south. The average time corresponding to no wind and no current conditions was assumed to be the average of the two, or 9.04 minutes, yielding the maximum towing speed of about 6.6 knots.

(iii) Flattop boat with negligible load: The total load in this test consisted of five people, weighing a total of about 800 lb. Waves were not significant but variable northerly winds of up to 8 knots were present during these tests. The times required to complete the test run going north was 7.45 minutes and going south was 6.41 minutes. The average time corresponding to no wind and no current condition was assumed to be the average of the two, or 6.93 minutes, yielding the maximum towing speed of 8.7 knots.

These results are plotted in Figure 16 to compare the effect of load upon the maximum speed of the FTB. As would be expected, increasing the load decreases the maximum speed in both the self propelled and

the towing mode. However, the effect of increasing load upon the maximum speed is progressively reduced. This is to be expected since the incremental increase in submerged surface area of the FTB with increasing load is least near the FTB's maximum loading capacity, and the drag force on an object moving through water depends upon the exposed area, but not upon the weight of the object.

The maneuverability of the UTB while towing the FTB was excellent, and both the FTB and the UTB handled well during these tests.

Turning Radius of the Flattop Boat

The turning radius of the FTB was determined using the boat's own engines and also by towing it astern with a UTB. In both cases, the engines were run at idling speeds, and in both cases the turning radius of the FTB was estimated to be about 30 feet. Idling speeds were necessary to minimize the turning radius.

Deployment and Retrieval of Boom from the Flattop Boat

(i) Deployment: The time required to deploy 900 ft of boom from the FTB using a UTB was measured under the no wind and no wave condition, and with the boom stored fore and aft, and athwartship. The faking and stacking of the boom fore and aft and deployment of the boom from this position over the rollers at the bow were felt to be both cumbersome and more difficult to carry out when compared with the athwartship position of the boom on the deck.

For deployment with the boom faked and stacked fore and aft, a crew of six men was required: two men in the utility boat (one man at the controls and the other watching the line from the samson post to the towing attachment of the boom), and four men on the FTB (one man at the controls and three men assisting boom deployment). The total deployment time for the 900-ft mixed boom measured from first connecting the line from the towing attachment to the post of the UTB to the dropping of the boom's free end in water was found to be approximately 8.83 minutes.

Since fore and aft faking and stacking of the boom is considered to be more difficult for deployment than the athwartship faking and stacking, the fore and aft faking is not recommended if the deployment is to be carried out over the rollers of the FTB. However, deployment of boom from the port side, if desired, should be easier if the boom is faked and stacked fore and aft, as determined during earlier tests, reference 8. However, two problems are anticipated in deployment from the port (or starboard) of the folding FTB. (1) If the inner and the outer railings of the FTB on one side are removed just prior to deployment and replaced immediately at the completion of deployment, then the deployment time will have to include time required for removal and

replacement of the two rails. This procedure is expected to take longer than the time required for deployment over the rollers at the bow. (2) Removal of rails from one side leaves three sides of the FTB with nothing for the crew to grab in case of emergencies, particularly under wind and/or wave conditions. Removal of rails for deployment/retrieval purposes is, therefore, not recommended for safety reasons.

If deployment of boom from the port side is considered desirable, as in reference 8, then it is recommended that the FTB design be changed by adding support rails on the bow and the stern, by removing bow and stern rollers, and by adding a roller on the port side.

For deployment with the boom faked athwartship, the number of people required was the same as with deployment of the boom when stored fore and aft. However, the time required to complete the deployment was 6.65 minutes the first time, and 4.30 minutes when the test was repeated. The difference of 2.35 minutes appears large as a percentage of the total time, but it really is small when it is considered that even small waves and winds makes it necessary for the crew to continuously maneuver the boats to keep the boom centered over the roller, which affects the time measurements in minutes rather than seconds. Wind and wave conditions were calm during these measurements; however, under measurable wind and wave conditions, the deployment and retrieval may take considerably longer than the time reported here.

Retrieval: For retrieval of boom from water to the deck of the FTB, a total of seven men was required. In addition to two men in a UTB required to assist whenever necessary, and one man at the controls of the FTB, four men were required to pull the boom out of water and fake and stack it on the deck. These latter four men worked in teams of two, alternating pulling the boom over the roller and faking the boom on the deck athwartship.

The retrieval test was carried out three times. The first time it took the crew 22.9 minutes and the last two times it took them 18 minutes to retrieve the 900-ft boom. At the end of each retrieval, the men were noted to be perspiring heavily, even when there were negligible wind and waves. In more normal weather conditions of a harbor, considerably more time may be required for retrieval than the 18 minutes recorded in the test program.

The boom retaining cylinders (guard pipes) were removed from the FTB during deployment, but these cylinders were used for keeping the boom centered on the deck during retrieval.

Transfer of Boom from the Flattop Boat to the Pier

The retrieval of the 900-ft boom from the FTB back to the pier was carried out under the calm condition of negligible waves and winds. Two men were required on the FTB to bring the boom towards the PAU and keep it in line with it. Six men were required on the pier: two men to

maintain the boom centered on the PAU and four men to pull the boom and fake it on the pier. This test was conducted twice: during the first test the time required to retrieve and fake the 900 feet of boom was 10.8 minutes, and upon repeating the test, the time was reduced to 9.9 minutes. The extra minute required during the first test may be ascribed to normal differences among tests of this kind. A few of the longer (48-inch) boom connectors required manual assistance in getting through the retaining bars of the PAU, which required varying amounts of time.

Towing Storage Bag

In addition to carrying and deploying the boom and the mooring system, and providing a work platform to operate the small skimmer system, the FTB may also be used to tow the towable storage bag (TSB) carrying the oil-water mixture from the spill site to the pier for transferring into a shore-based storage container. The FTB was tested to determine its effectiveness in towing the 30-ft long Kepner Sea Container. Details of this TSB are given in reference 9.

It was felt that the testing of the FTB in this test program should be limited to those applications which did not require structural changes in the design of the FTB. Such changes would have required a major design effort which (1) was clearly outside the scope of the present test program, and (2) should be carried out only if and when the specific application of the FTB has been accepted by the Navy as desirable.

Two methods of towing the TSB were considered: astern and alongside the FTB. The towing of TSB alongside the port or starboard was rejected for a number of reasons: (1) a safe way to tie the TSB to the FTB could not be found, (2) the TSB was longer than the FTB and it was considered unsafe to tow the TSB alongside for possible damage to or from the propeller during maneuvering the FTB, (3) holding the TSB a safe distance away from the FTB would have required major structural changes in the FTB, and (4) the drag forces created by the full TSB could have caused significant maneuvering and towing problems for the FTB.

To permit towing the TSB astern the FTB, a bridle assembly was used around the two boom-retaining posts on the FTB, and another bridle assembly was used at the larger end of the TSB. A towing length of approximately 50 ft was used. Prior to the test runs, the bag was filled with a mixture of 50 percent fresh and 50 percent seawater.

During towing, the TSB was maneuvered very well. The line slid around the FTB's boom-retaining posts well during turning. The TSB was very stable; neither fishtailing nor porpoising were observed, Figure 17. A crew of two men was found to be adequate for this application.

The maximum speed run was carried out over a measured distance of 0.367 nautical miles. Running north, the run was completed in 4.78 minutes whereas it took only 3.74 minutes going south. The winds and

waves were minimal. Based upon these measurements, it was estimated that the FTB could tow the TSB at a speed of approximately 5.2 knots under negligible winds, waves, and currents.

Connecting and Disconnecting Sections of Boom

The FTB could also be used to connect and disconnect sections of boom. This was accomplished by first standing on the work platform, bending to pick up the boom connection, and bringing it over the FTB rollers. Then, it took two men less than 15 seconds each to complete connect and disconnect operations in calm water conditions. A third man was required at the FTB controls. A pair of pliers and adjustable vice grips are required tools to disconnect the boom sections.

Handling and Storage of the Flattop Boat

Handling: The procedures for unfolding the FTB on land prior to deployment and for folding it prior to transportation are described in detail in Appendix C. The FTB purchased for these tests weighed 5,240 lb whereas the trailer weighed 2,200 lb. The combined weight of 7,440 lb is easily transportable on land by a truck capable of pulling approximately 8,000 lb on a highway. No special permit is required for land transportation of the FTB in the folded position. Other handling details are given in Appendix C.

Storage: Because the deployment and the retrieval of the folding FTB is carried out over a ramp, requires no tools, and takes only a few minutes, it appears best to store the FTB on land. Also, possible damage to the FTB in water under adverse weather conditions, mooring requirements, and effect of seawater upon the FTB components suggest that storage on land would be superior to storage on water. If the FTB is stored on land, no special protective equipment is felt necessary; a thorough wash with fresh water after each use should be adequate.

No special tests were devised to determine if (a) the means of attaching the working surface of the FTB to the pontoon are structurally adequate, (b) the strength of the working surface of the FTB is adequate, and (c) the working surface is sufficiently dent-resistant. However, the test program did not uncover any obvious design problems.

Observations, Comments, and Suggestions

A number of design changes were suggested by the manufacturer prior to the start of the test program. The need for improvements in these areas became readily apparent during the test program. The following suggestions and observations made by the crew also incorporate suggestions made by the manufacturer.

1. The hinges holding the control panel were too weak and had to be reinforced for the test program, Figure 18. The manufacturer recommends that the present swing-open control panel should be changed to a quick-disconnect electrical fitting and the panels should be rigidly bolted to the deck during use.

2. The plywood panels on the inner and outer rails appear unnecessary. It was felt that under heavy wind conditions they may act as sails and reduce maneuverability of the boat. Instead, a fence type barrier should be provided. If the panels are considered important for some reason, their border joints should be improved, Figure 19.

3. The hasp latch and lock on the deck of the FTB protrude above the surface of the deck thereby posing a hazard to men, boom, and other equipment, Figure 20. They should be removed and replaced by lock and handle combinations which are flush with the deck.

4. The deck of the boat is dent resistant. A 36-inch boom connector fell on the deck of the FTB from a height of about 6 ft and landed with its edge first, thereby causing a dent mark of only about 1" x 1/2" x 1/4" deep.

5. Although antiskid surfaces were not investigated in this test program, it is felt that it would be necessary to have an antiskid deck during actual oil spill cleanup situations.

6. The FTB did not have rubber bumpers. Although not tested in this test program, it is felt that rubber bumpers should be provided. If rubber bumpers are not acceptable, then the boat should have fenders on both the port and the starboard sides.

7. Backing down with a full load should be done slowly so as to prevent water from washing over the transom.

8. A locking mechanism should be installed on each roller so that the roller could be prevented from turning when a crew member stands on it inadvertently. This should be a required safety feature.

9. To minimize the risk of damage to the rollers, the rollers should not project out of the boat frame.

10. All cleats should be flush with the deck, in a recess, to minimize risk of damage during folding and unfolding the boat.

11. Lifting the FTB out of water by a crane is not recommended.

12. The railings are too light, and they might not withstand a man's impact in adverse weather conditions. It is recommended that the railing

supports on the deck be closer together and that the vertical members of the railings be heavier and fastened to the deck with two side flanges instead of deck flanges.

13. The deck folding hinges are weak. The "Strap Hinges" should be replaced by "T-Butt" hinges.

14. The only advantage of the folding boat appears to be that it does not require a special permit for land transportation. The disadvantage of the folding boat is that it cannot be safely deployed with a crane. However, its deployment over a ramp is fast and simple.

15. The manufacturer states that the boat is designed to be flexible in order to improve load distribution. Therefore, according to the manufacturer:

a. Any effort to strengthen the FTB will make it rigid, and, therefore, weaken it.

b. The lifting sling of the FTB must be used to fold and unfold the boat. Other methods may damage the hinges.

c. Lifting eyes are not provided because the boat is not rigid.

d. Rollers should not be placed on the underside of the decks to facilitate deployment.

16. The FTB was felt to be stable, at least under the relative calm conditions of the Port Hueneme harbor. The total power of the two 75-hp engines was considered to be adequate for the use of the FTB in harbor oil spill cleanup situations.

17. The FTB could be used for towing towable storage bags, for deploying and retrieving boom mooring systems, for connecting and disconnecting boom sections, for transporting men and equipment between pier and spill site, and for transporting, deploying, and retrieving boom.

18. The removable inner rails of the FTB permit an increase in the usable deck area, if necessary. However, when the inner rails are in place, they provide safe walkways on both the port and the starboard sides as well as access to the storage areas and the fuel tanks.

19. For the most effective use of the deck space for boom storage, the specifications of the Navy boom and the FTB should be coordinated to that the usable width of the FTB (or the usable length if fore and aft faking is planned in future FTB design) will be slightly in excess of an

integral multiple of the length of the boom floats at which the boom could be easily folded without damage to flotation.

20. The FTB should be stored on land when not in use.

Evaluation of the Mooring Systems

Description of the Systems

The three mooring systems evaluated in this test program were manufactured by Seaward International, Inc., Falls Church, Virginia. Each mooring system consisted of an anchor, a buoy, a crown buoy, and appropriate size lines. The three mooring systems were designed for nominal holding forces of 2,000 lb, 5,000 lb, and 10,000 lb which, for simplicity, will be identified as small, medium, and large, respectively. The buoys of these mooring systems were designed to have an additional 100-percent reserve buoyancy to prevent submergence of the boom. The Danforth anchors of the small, the medium, and the large mooring systems weighed 12 lb, 40 lb, and 60 lb, respectively. The three mooring systems are shown on pallets in Figures 21, 22, and 23, whereas their design details are given in Figures 24, 25, and 26.

Description of the Tests

The test of the mooring systems consisted of several elements which are listed in WBS-6 of Appendix A. To complete these tests, the three mooring systems were deployed in and retrieved from the Port Hueneme Harbor using the UTB as well as the FTB. The 900-ft long mixed boom was used to simulate oil containment around a ship between the pier on one side and the boom on the other side, and also to simulate surrounding an oil slick in the middle of a harbor, away from a pier or other structures. The last element consisted of dragging each anchor on the sandy Port Hueneme beach to determmine its holding capacity.

The deployment and retrieval procedures, the difficulties encountered, and the suggested modifications are given below.

Deployment of the Mooring System using a Utility Boat

Of the three mooring systems, only the small mooring system was found to be deployable from the UTB. The medium and the large mooring systems could not be safely deployed from this boat because of their size and weight.

Before deploying the small mooring system, it was decided to remove the mooring line from around the buoy and have it in a coiled form on the UTB with reverse twists in the line. This was felt to be a safer, less

cumbersome procedure, and all hands felt that the possibility of twists in the mooring line, after the mooring line has been placed in the water, would be minimized. Furthermore, wrapping the line around the buoy in a neat fashion at the end of use will require equipment to rotate the buoy slowly. It was, therefore, felt that a recommended method of storing all lines to prevent entanglement will be to coil them with reverse twists put in the lines as they are coiled, or fake them in a figure eight configuration. This recommendation is in disagreement with the findings of reference 8.

For deployment, the anchor, thy crown buoy, and the crown line were dropped into the water from the bow at a predetermined location. The location of the anchor was estimated from the desired location of the boom and the lengths of the mooring lines. The mooring line was then payed out as the UTB slowly backed away from the anchor location. The length of the properly weighed mooring line should normally be about six times the depth of water to ensure that the weight of the mooring line can maintain a zero degree angle with the horizontal at the anchor. The procedures for design of the mooring line is given in detail in a NAVFAC design manual, reference 10. For CEL testing, however, no attempt was made to change the length of the lines to conform to the above guidelines, to enable the mooring systems to be further tested at other Navy bases after the completion of this test program.

As soon as the end of the mooring line was reached, the buoy was dropped into the water. The free end of the buoy was already carrying the mooring line to connect the buoy to the boom, which was attached to it through a shackle. To connect the mooring line to the selected boom connector, it was necessary to drill a hole into the bottom end of the connector. Of course, this hole was drilled prior to deployment of the boom from the pier. The size of the hole was determined from the size of the eyebolt required for the shackle. The eyebolt and the shackle sizes, of course, will depend upon the mooring system finally selected by the Navy.

The mooring lines used to connect the buoy to the boom were 3/4-inch diameter, polyester cover, polypropylene core, 2-in-1 stable braid, with a thimble at one end. The entire deployment of the mooring system required three people in the UTB: one to operate the engine, one to ensure that the lines were not entangled when paying out, and the third to hold the line going into the water over the bow. Because the purpose of the mooring line between the buoy and the boom is to minimize drift of the boom from the desired position, particularly in rough weather, the length of this line should be as short as possible. An estimated 10 to 15 feet of mooring line to connect the buoy to the boom appears to be adequate.

Retrieval of the Mooring System using a Utility Boat

The small mooring system was retrieved using the UTB by first maneuvering the UTB so that the operator could bend over the side of the

UTB and grab the crown line or the crown buoy. The crown line was then fastened to a cleat on the UTB, and the UTB was slowly backed away from the anchor location, but in a direction opposite to that used during deployment. In a few minutes, the anchor was pulled loose from the bottom, the crown line was removed from the cleat, and the anchor was retrieved by two men. Upon completion of the anchor retrieval, the mooring line between the buoy and the anchor was slowly retrieved as the boat was propelled towards the buoy. Next, the buoy was pulled inside the boat. The boat was then maneuvered towards the boom connector, two men bent down and pulled the boom connector at the side of the boat out of the water, disengaged the shackle, and lowered the boom gently into the water.

No special precautions were felt necessary, particularly because there were no waves or winds on this day.

Deployment of the Mooring Systems from the Flattop Boat

The medium and the large mooring systems were deployed from the FTB. The deployment procedure and the number of men required were similar to those used during the deployment of the small mooring system.

In tying the first end of a line, an alternative to shackles may be used. This can be done by passing the loop of the line through the eye and then the bitter end of the line through the loop, as shown in Figure 27.

Retrieval of the Mooring Systems from the Flattop Boat

Although the medium and the large mooring systems were bulky and heavy, the retrieval procedure was similar to the one used during retrieval of the small mooring system using the UTB. For deployment and retrieval of the anchors, two strong men were required, in addition to one man at the propeller controls.

Maximum Force Exerted by the Utility Boat against the Mooring System

The maximum force that a UTB can exert against a mooring system (or against any fixed object for that matter) was determined by tying a line between the samson post of the UTB and a piling through a dynamometer. The engine was then run full throttle and the maximum reading on the dynamometer was recorded. The maximum load exerted on the dynamometer was 1,000 ± 20 lb.

As indicated earlier, the engine power appears to be less than desirable for operation in harbor areas, particularly if winds, waves, and/or currents are present.

Mooring Requirements to Encircle a Ship and to Contain an Oil Spill in the Middle of a Harbor

The mooring requirements to encircle a ship will depend upon the type of pier at which the ship is berthed. If the pier is open, i.e., water can go under the pier to the other side, then the mooring requirements will be more extensive.

During these tests, the ship available for tests was tied to a "closed" pier (defined as one which has a vertical barrier in the water along the length of the pier). In this situation, all that was necessary was to tie one end of the boom to a specific piling at or close to the vertical wall to ensure that oil would not escape at this end, then proceed to deploy the boom such that it surrounded the oil and the ship completely, Figure 28. Two mooring systems were deployed at about the same time using the FTB so that the boom could be secured at desired locations. The other end of the boom was connected to a suitably selected piling at the other end of the ship. The boom was therefore secured at four points: two pilings and two mooring systems.

To encircle a ship completely and to contain a spill in an open area away from all structures, a minimum of four mooring systems are felt to be necessary. Two additional small mooring systems available for tests were, therefore, used for this test. The boom, moored by the four mooring systems, assumed a nearly circular shape, as shown in Figure 29. Several observations made during these tests and recommendations developed are given later in this chapter.

Holding Capacity of Anchors

Due to limited access to a soft clay seafloor, the anchors were tested only in sand. Capacities of the anchors in other types of seafloors may be inferred from the results of the tests in sand.

The holding capacities of the 16-lb, 40-lb, and 60-lb anchors in sand were calculated from their holding capacities determined by dragging each anchor slowly on the sandy beach at Port Hueneme by a Caterpillar bulldozer, Figure 30. This is recognized to be a better procedure for obtaining reliable, reproducible data on the anchors than conducting these measurements in the harbor. The standard procedure used in these tests is described in detail in reference 11.

During the test, once the anchor behan to move through the beach sand, the maximum pull exerted by it upon the line was measured by a dynamometer. Each anchor was pulled over a distance of approximately 50 ft. The 16-lb and the 40-lb anchors indicated maximum holding capacities of 2,850 $\pm$ 50 lb and 7,550 $\pm$ 50 lb, respectively. The 60-lb anchor broke off at 10,000 $\pm$ 50 lb. The fluke was found broken from the crown.

For a particular type of soil, the holding power of a Danforth anchor in a harbor is about 34 percent lower than its holding power on

the beach, reference 12. Therefore, the small, the medium, and the large anchors may be expected to hold only about 1,740 lb, 4,600 lb, and 6,600 lb in the harbor, respectively.

Holding Capacity of the Mooring Systems

The holding capacity of an entire mooring system depends upon the holding capacity of the anchor, the ratio of the length of the mooring line to the depth of water, the type of soil in the harbor, and the weight of the link chain at the anchor. The effect of these factors upon the overall effectiveness of these mooring systems was estimated as follows:

First, for the purpose of these tests, the harbor was assumed to have a sandy soil, as noted earlier. The effect of other types of soil will be estimated later. Second, the length of the chain in each of the three mooring systems, Figures 24, 25, and 26, was too small to make a meaningful contribution in reducing the angle between the mooring line and the bottom terrain. Their effect was, therefore, neglected. Third, although Figures 24-26 show these mooring systems to be suitable in up to 100-ft depths, most harbors have water depths less than 50 ft. Therefore, a maximum water depth of 50 ft was assumed in these calculations.

The 315-ft nylon line of the small mooring system and the 420-ft nylon lines of the medium and the large mooring systems yield angles of approximately 9.1 and 6.8 degrees with the horizontal, respectively. For a 6-degree angle, the holding power of the anchor is reduced by about 15 percent whereas for a 12-degree angle, the holding power of the anchor is reduced by about 38 percent, references 10-12. Therefore, for the small, medium, and large mooring systems, the holding powers of the anchors was assumed to be further reduced by approximately 27 percent, 16 percent, and 16 percent, respectively. Therefore, the holding powers of the small, medium, and large mooring systems shown in Figures 24, 25, and 26, in a sandy seafloor, with a water depth of 50 ft, may be assumed to be only approximately 1,300 lb, 3,900 lb, and 5,500 lb, respectively.

In a water depth of 100 ft, the angle formed by the mooring line, with the horizontal, of the small, medium, and large mooring systems will be 18.5 degrees, 13.8 degrees, and 13.8 degrees, respectively. At these angles, it is quite likely that the anchors may not bury in the sand at all.

The holding capacities of the anchors in clay or a silty seafloor may be lower by a factor of 3 to 7 than those estimated in sand as a result of the beach test, references 12-13. If a factor of 7 were used to determine the holding capacities of anchors in mud, then the small, medium, and large mooring systems could only be able to hold less than 190 lb, 560 lb, and 790 lb, respectively. Most harbors, of course, do not have a pure clay or a pure sand seafloor.

Therefore, actual holding powers of these mooring systems in harbors may be somewhat better than the 190 to 790 lb estimated above.

General Observations

The mooring systems were all found to be compatible with the 36-inch Bennett U. S. Navy boom. The easiest and the most desirable procedure of attaching the mooring system to the boom connectors was by using a shackle at the end of the line and attaching it to an eyebolt located at the bottom end of the boom connector. To permit flexibility, all boom connectors should have suitable eyebolts attached to them or have suitably sized holes through which an eyebolt could be fastened.

Under the conditions of the tests, no bridle assembly was required to stabilize the boom. If the mooring lines do not have twists in them, there is little reason to suspect that the boom may require additional stabilization. The absence of twists can be ensured if the lines are first "untwisted" and then stored in a figure eight configuration.

Including a person at the controls, a minimum of three people were required to deploy and retrieve the mooring systems. The time required to complete deployment or retrieval of all mooring systems was about the same, and found to be approximately 15 minutes, including the time required to moor the line to the boom. However, this time is considered to be quite variable, and it will depend strongly upon the location of the spill, waves, currents, winds, depth of water, and skill, training and motivation of personnel.

Wrapping the line around the buoy for storage is not recommended because of several problems. (1) If the line is stuck onto the buoy, pulling with a boat may not be enough to unwind it. This was found to be the situation in one of the tests. (2) If the line has the slightest amount of slack in it, it may all come off the buoy at the same time and cause entanglement. (3) To wind the line around the buoy in a neat fashion will require a mechanical device to turn the buoy slowly. Otherwise, the procedure will be cumbersome. (4) If the entire length of line goes into the water at one time, the operator has just about lost all control of the line which may, in some situations, come too close to the propeller.

The procedure of coiling a line with reverse twists on the deck of the boat avoided twists and entanglements in the line during its actual use in a harbor, but the procedure was felt to be not as easy as faking the line in a figure eight configuration. Therefore, it is recommended that all lines be stored in a figure eight configuration.

To completely surround a ship berthed at a pier may require a minimum of three mooring systems if the ship is large and if the weather is adverse, Figure 31. Under calm conditions and for a smaller ship, two mooring systems may be adequate, Figure 32. In both cases, two pilings are also used for securing purposes. To completely contain a spill in an open area, four mooring systems are considered desirable if the winds and currents are variable, Figure 29. If winds and currents are

predictable, and if the spill is planned to be removed in a short time, then a catenary configuration requiring only two mooring systems should be adequate.

Observations, Comments, and Suggestions

Based upon CEL's test experience, the following recommendations are made:

1. The length of the mooring line between the buoy and the boom should be as short as possible. An estimated 10 to 15 feet of this line appears reasonable to minimize drift of the boom. The mooring line connecting the boom to the buoy should be 100 percent polypropylene so that it floats freely on water, and facilitates retrieval.

2. The location of the anchor should be predetermined from the desired location of the boom and the length of the mooring line. The anchor should be dropped first prior to mooring the line to the boom, per paragraph 3.3.2.1 of reference 8.

3. The deployment of the boom and the mooring systems should be carried out simultaneously so that the boom can be secured during deployment, particularly in bad weather, to prevent boom drifts due to winds and currents.

4. All boom connectors should have sized holes at the bottom end to match appropriate eyebolts. Eyebolts, which may be attached to all connectors prior to boom deployment or to selected connectors only during mooring, should match the shackle suitable for the selected mooring system.

5. All lines should be faked into a figure eight configuration for storage to minimize twists and risk of entanglement.

6. Bulkhead attachments should be prepositioned at all piers where oil spills are expected to occur. The selection of pilings for bulkhead attachments should be carried out carefully to ensure that the selected locations will not leave space through which oil could escape due to currents, winds, or waves.

7. The end connector on the boom should match the bulkhead attachment. The bulkhead attachment has a female connector and, therefore, it must be coupled to a male connector. If the boom to be connected to the bulkhead attachment has a female connector, a "double-male" adapter must be joined to the bulkhead attachment. Of course, the towing assembly must be removed prior to securing the boom to the bulkhead attachment.

8. To encircle a spill in an open area, care should be taken to ensure that one end of the boom has a female end connector whereas the other end of the boom has a male end connector.

9. Several different adapters should be stored at the base to cater to all possible eventualities.

Best Size Mooring System for 1,000 ft of 36-inch Boom

To determine the best size mooring system for 1,000 ft of 36-inch boom under the conditions given in reference 14 (winds: 25 knots; waves: 1 ft (height of the 1/3rd highest waves) current: 2 knots), the procedure given in reference 15 was used to calculate the maximum force on the boom in a catenary configuration with a 65 percent opening. Using a freeboard of 12 inches and a skirt depth of 24 inches, the maximum force that the boom may exert on the two mooring systems is approximately 32,000 lb, or 16,000 lb on each of the two mooring systems.

As noted earlier, the large mooring system evaluated in this test program will hold approximately 5,500 lb in a sandy seafloor, but as little as 790 lb in a clay or silty seafloor. It was, therefore, felt necessary to select the largest available mooring system that can be handled by two men, without mechanical equipment, in rough weather. An anchor to hold 16,000 lb in a harbor is felt to be too heavy for two men to deploy or retrieve from the FTB without the use of a winch. Instead, it was assumed that an 80-lb Danforth anchor attached to a 10-ft long, 3/4-inch link chain is about the maximum weight two men could deploy and retrieve from a FTB in rough weather.

Assuming further that (a) the harbor has a sandy seafloor, (b) the water depth does not exceed 50 ft, (c) the link chain provides weight to the mooring line to help set the anchor initially, but it does not help in reducing the angle of the mooring line with the horizontal, and (d) a 420-ft length of 1-1/8-inch-diameter nylon mooring line is used, the holding power of the 80-lb anchor, in a sandy seafloor, of 10,000 lb, reference 12, may be reduced by about 16 percent tp approximately 8,400 lb. Whenever the current and wind conditions cause a drag exceeding about 8,400 lb on each of the two anchors holding the 1,000-ft boom in a catenary, the anchors will begin to drift slowly. In a harbor with a sandy seafloor, the two 80-lb anchors could hold the boom in position when the current is approximately 1.2 knots and winds are negligible, or when the current is approximately 1.0 knot under 25-knot winds. If the seafloor is clay or silty, however, the holding power of the 80-lb anchor may be reduced to as low as 1,200 lb. Once this load is exceeded, the anchor can "ball up", become clogged, and after it has come out, will not penetrate again unless cleaned of the clog.

If heavier mooring systems are desired to withstand currents up to 2 knots under 25-knot winds, or if a clay seafloor is anticipated, then it will be necessary to select heavier anchors and link chains, requiring

mechanical equipment for their deployment and retrieval. Alternatively, multiple anchors may be used in tandem.

Evaluation of the Sorbent Distribution System

The original Work Breakdown Structure on the Sorbent Distribution System, reference 3, was reduced in scope in order not to duplicate the work completed earlier by NAVWESA, reference 8. This earlier work showed that the sorbent distribution system was satisfactory in all respects except that it generated unacceptable amounts of dust under wind conditions. Accordingly, the CEL test consisted of building a hopper, referred to here as a bin, of about the same dimensions as the one tested in reference 8, modifying the bin to reduce dust under wind conditions, and then subjecting the designed hardware to a laboratory test and evaluation.

Three modifications were tried; (1) using a cover to reduce the top opening of the bin, (2) adding a tapered hopper on top of the bin, and (3) a sorbent material-loader boot assembly mounted on the bin. The construction drawing of the bin and the tapered hopper is given in Figure 33 whereas the construction drawing of the boot is included in Figure 34. There are two items of special interest in these designs.

a. The horizontal grate in the bin opening was designed to ensure that if the sorbent bag were released or dropped accidentally, it would not affect the agitator mechanism of the bin.

b. The hopper and the boot assemblies were designed high enough so that the filling-up operation is conducted by the operator from the standing position which is easier and safer, rather than the knee-bent position.

An air speed of 15 knots generated by a blower to simulate ambient winds was considered adequate for these tests. The air speed was measured by an Alnor Thermo-Anemometer, type 8500. The determination of the effectiveness of these modifications in reducing the dust level was carried out visually.

The first test consisted of pouring a 4-cu ft, 24-lb bag of EKOPERL, manufactured by Metropolitan Petroleum Petrochemicals Co., Inc., 25 Caven Point Road, Jersey City, N.J., 07305, into the bin through the grate. Prior to pouring the sorbent, the blower speed was adjusted to simulate a 15-knot wind condition at the bin. After holding the EKOPERL bag on the bin's grate, the operator sliced open the bag with a knife. The bin is shown in Figure 35. Although the dust level is not visible in Figure 35, visual observations and a motion picture record clearly showed that the dust level was high and not likely to be acceptable. It required one man approximately 40 seconds to completely empty one bag of EKOPERL into the bin.

In the second test, the tapered hopper was rigidly bolted to the bin, and the sorbent bag was held half inside the hopper prior to slice-opening the bag, Figure 36. There was no noticeable improvement in the dust level. The manpower and time required were both similar to the first test.

For the third test, a vinyl-coated polyester thread fabric boot, Figure 34, was fastened to the bin. During this test, the sorbent bag was first sliced-open at the top while still resting on the floor, the boot was pulled over it about half way, the drawstring was pulled around the sorbent bag, and then two men lifted the sorbent bag and turned it upside down into the boot, Figure 37. During this operation, the drawstring was held tight against the sorbent bag to minimize dust formation. When the sorbent bag was empty, it was slowly pulled out of the boot, and the drawstring was pulled tight to close the boot opening. Visual observations and motion picture records showed a very substantial reduction in the dust level, when compared with the dust level observed in the two earlier tests.

These tests were designed simply to investigate and demonstrate viable method(s) of reducing dust levels. The boot design was found to be promising and it is felt that this concept should be explored further by constructing the boot out of a more flexible material to improve handling.

The pouring of one bag of sorbent material using the boot assembly took two men approximately 50 seconds in 15-knot winds. The time was measured from slice-opening the sorbent bag to removal of the empty bag from the boot assembly.

Comments and Observations

Based upon tests, the following observations are made:

1. The boot shown in Figure 37 but with a somewhat shorter length should be investigated, so that the top of the boot is within the reach of the operator.

2. More flexible boot materials should be investigated.

3. If breathing masks and protective goggles are worn during the time the sorbent system is in use, then the modification of the sorbent problem may not be necessary.

4. Larger size EKOPERL sorbent particles should be considered to minimize the hazard to operators. Should this be considered, the mechanism of the sorbent dispenser may have to be redesigned.

CONCLUSIONS

Power Assistance Unit

1. The PAU was useful during boom deployment and retrieval.

2. The foot tire control mechanism is not safe because during an emergency it is necessary for an operator to press the control to stop the tire from rotation.

3. To use the PAU for boom deployment, it is necessary to physically remove the drive chain to permit free tire rotation.

4. The boom may not be retained on the tires during deployment and retrieval without the boom retaining modification fabricated for these tests.

5. To protect the boom from damage, it is necessary to use a chute on the PAU and to place the PAU so that it clears the pier, pilings, and all protrusions from the pier and pilings.

6. If the PAU is not rigidly fixed, it may topple over and fall into the water during use.

7. There is no nonskid walking surface around the PAU for operator safety. In tests, a 4' x 8' x 3/4" thick plywood sheet was used.

8. The tow line, the boom, and the boom connectors kept getting entrapped in the spaces between the tires.

9. The selection of a pier and the location of the PAU on the pier will determine the ease with which boom could be deployed and retrieved.

10. The absence of a mechanism to turn the PAU in the direction of the boom makes its use difficult under wind and/or current conditions.

Utility Boat

1. The UTB could be readily deployed and retrieved by a crane.

2. The UTB could be damaged when it hits pilings and other objects if fenders are not used.

3. The speedometer was not found to be useful in UTB operations.

4. The deck of the UTB could become very slippery, and therefore unsafe, during harbor oil spill removal/recovery operations.

5. Towing boom from a samson post - fairlead arrangement instead of the transom of the UTB significantly improved the maneuverability and the stability of the UTB. However, both the samson post and the fairlead were felt to be too high.

6. In a straight run with maximum throttle with no load, one 6-gal fuel tank lasted only 39.2 minutes. While towing the 900-ft mixed boom at maximum throttle, however, the same amount of fuel lasted 49.75 minutes. One fuel tank may, therefore, be insufficient for uninterrupted operation of the UTB in harbor oil spill situations.

7. Caution must be observed to ensure that the towing line does not get entangled during paying, retrieval, and/or storage.

8. The fairlead caused wear of the tow line at the point of contact which required frequent changes in the tow line contact point.

9. The life of UTB outboard engines (Johnson 85 hp) is drastically reduced if they are run continuously at full throttle.

10. A towing length of 50 ft was found to be adequate under the calm conditions of the Port Hueneme harbor.

11. The UTB could be used to tow a full oil storage bag, to connect and disconnect boom sections, to tow a FTB, and to deploy the small mooring system.

12. Lines of 3/4-inch diameter, polyester cover, polypropylene core, 2-in-1 stable braid were found to be adequate for all towing operations. However, these lines do not float.

13. The size of the UTB is not adequate to deploy the medium and the large mooring systems.

14. The outboard engine's outboard cooling system becomes easily clogged with debris found in harbors.

15. The holding power of the UTB with an 85 hp Johnson engine is 1,000 lb.

16. The UTB appears to lack stability, and the 85 hp Johnson engine appears to lack power for cleanup operations under less than perfect weather conditions. Extreme caution is required even under near-perfect weather conditions.

Flattop Boat

1. The following measurements were carried out on the FTB:

Weight of the FTB, without the trailer	= 5,240 lb.
Weight carrying capacity of the FTB	= 4,350 lb.
Usable deck area of the FTB	= 228 sq ft.
Safe capacity of FTB for carrying the 36-inch Navy Bennett boom.	= 500 ft.
Turning radius of the FTB	
(i) when self-propelled	= 30 ft.
(ii) when pulled by a UTB	= 30 ft.

2. The hinges holding the control panels are too weak.

3. The plywood panels on the inner and outer rails appear unnecessary. It was felt that under heavy wind conditions, they may act as sails and reduce maneuverability of the FTB.

4. The hasp latch on the deck of the FTB protrudes above the surface of the deck thereby posing a hazard to men, boom, and other equipment.

5. The deck of the FTB is not skid-proof, and therefore unsafe for use in harbor oil spill removal/recovery operations.

6. The deck of the boat is dent resistant.

7. The FTB did not come with rubber bumpers to protect it from damage during use.

8. There is a serious danger of crew members slipping on the free-rolling boom deployment rollers.

9. Backing down with a full load should be done slowly so as to prevent water from washing over the transom.

10. There is a risk of damage to the rollers because they project out of the frame of the boat.

11. There is a risk of damage to the FTB during folding and unfolding from the cleats because the cleats project above the surface of the deck.

12. A safe method of deployment and retrieval of the FTB with a crane was not available. However, for deployment and retrieval, the use of a ramp was found to be fast and simple.

13. The railings are too light, and they might not withstand a man's impact in adverse weather conditions.

14. The deck folding hinges appeared to be weak.

15. According to the manufacturer, the boat is designed to be flexible in order to improve load distribution. Therefore, according to the manufacturer:

a) Any effort to strengthen the folding FTB will make it rigid and, therefore, weaker.

b) The lifting sling of the FTB must be used to fold and unfold the boat. Other methods may damage the hinges.

c) Lifting eyes are not provided because the boat is not rigid.

d) Rollers should not be placed on the underside of the deck to facilitate deployment.

16. The FTB was found to be stable, and the total power of the two 75 hp engines was found to be adequate for the use of the FTB in harbor oil spill cleanup situations.

17. The usable width of the FTB is not an integral multiple of the length of the boom floats at the end of which the boom could be easily folded without damage to flotation.

18. The FTB could be used for transporting people and equipment, for towing a towable storage bag, for deploying and retrieving boom mooring systems, for connecting and disconnecting boom sections, and for transporting, deploying, and retrieving booms.

Mooring Systems.

1. The three mooring systems, small, medium, and large, were found to be compatible with the 36-inch Bennett U.S. Navy boom.

2. The length of the mooring line connecting the boom to the buoy should be small to minimize drift of the boom in wind, wave, and current conditions.

3. The crown and the mooring lines were stored in coils with reverse twists in the lines to minimize the risk of entanglement during deployment.

This was found to be a preferred method of storing compared with wrapping the line around the buoy.

4. Eyebolts are required at the bottom end of the boom connectors which match shackles at the end of the mooring lines.

5. Under calm weather conditions, no bridle assembly was required to stabilize the boom.

6. Three people are required to complete deployment and retrieval of the boom mooring system, including one person on the engine controls of the FTB or the UTB used for deployment and retrieval. The time required to complete deployment or retrieval was approximately 15 minutes under negligible wind, wave, and current conditions.

7. The UTB could exert a 1,000-lb pull against a mooring system.

8. To confine an oil spill at a "closed pier" defined as one which has a vertical wall along the length of the pier, two mooring systems are adequate when the ends of the boom are secured to pilings through bulkhead attachments.

9. To confine an oil spill at an "open pier", defined as one under which water can pass from one side to the other, the boom may require three mooring systems and two bulkhead attachments if the ship is large and the weather is adverse. However, under calm weather conditions and for a smaller ship, the above requirement may be reduced by one mooring system.

10. Four mooring systems are required to encircle a ship completely or to contain an oil spill in an open area away from all structures.

11. If the winds and the currents are relatively mild, and if the spill is planned to be removed in a short time, then a catenary configuration requiring only two mooring systems should be adequate.

12. For mooring medium and large mooring systems to the boom, 3/4-inch-diameter, polyester-cover, polypropylene-core, 2-in-1 stable-braid lines were found to be adequate. However, these lines do not float.

13. The holding capacities of the three mooring systems were estimated as follows:

Mooring System	Holding Capacity (lb)		
	Anchor on a Sandy Beach	Mooring System in a Harbor with a Sandy Seafloor	Mooring System in a Harbor with a Clay or Silty Seafloor
Small	2,850	1,300	190 - 420
Medium	7,550	3,900	560 - 1,300
Large	10,000	5,500	790 - 1,800

14. In most harbors, the mooring systems evaluated in this test program are not likely to be able to hold a boom in a catenary configuration under winds and/or current conditions.

15. The heaviest mooring system that could be deployed and retrieved from a FTB by two men, without a winch, was determined. It includes an 80-lb Danforth anchor, a 10-ft long, 3/4-inch link chain, and a 420-ft long, 1-1/8-inch-diameter nylon mooring line. This system is expected to hold about 8,400-lb in a sandy seafloor.

Sorbent Distribution System

1. To minimize the risk of sorbent dust generation under wind conditions, a boot assembly of the type investigated during this test and evaluation is necessary.

2. If breathing masks and protective goggles are worn during the time the sorbent system is in use, then the modification of the sorbent system tested by NAVWESA, reference 8, may not be necessary.

3. Larger size EKOPERL particles may reduce the dust hazard.

Time and Manpower Measurements

1. The time and the manpower required to deploy and retrieve the 900-ft mixed boom from a pier using a UTB and the PAU are given below:

Operation	Number of Men on Pier	Number of Men in UTB(s)	Time to Complete Operation (Min)	Winds (Knots)	Waves (Ft)
Deployment	4	2	8.67	Neg *	Neg
Retrieval	6	4	15.05	5	Neg

*Neg. = Negligible

2. The time and the manpower required to deploy and retrieve the UTB, and the maximum speed that the UTB could maintain while towing the 900-ft mixed boom in a straight line and in a catenary configuration are given below:

Operation	Number of Men	Time to Complete Operation (Min)	Max. Speed (Knots)	Winds (Knots)	Waves (Ft)
UTB deployment from pier	4	2.5	---	Neg	Neg
UTB retrieval from pier	4	3.0	---	Neg	Neg
Straight line tow	2	---	3.76	Neg	Neg
Catenary tow with 65% opening	4	---	1.08	Light	1/2

3. The FTB could tow a full towable storage bag at a speed of approximately 5.2 knots under negligible winds, waves, and currents.

4. The time and the manpower required for connecting and disconnecting sections of boom from a UTB and from a FTB are given below:

Operation	Number of Men	Time to Complete Operation (Min)	Winds (Knots)	Waves (Ft)
Connect boom sections from a UTB	3	0.25	Neg	Neg
Disconnect boom sections from a UTB	3	0.25	Neg	Neg
Connect boom sections from a FTB	3	0.25	Neg	Neg
Disconnect boom sections from a FTB	3	0.25	Neg	Neg

5. The time and the manpower required to deploy and to retrieve the FTB, load and unload the FTB with the 900-ft mixed boom, deploy and retrieve the boom from the FTB, and the maximum speeds that the FTB could maintain when self-powered and when pulled by a UTB, when fully loaded, partially loaded, and not loaded, are given below:

Operation	Number of Men Required	Time to Complete Operation (Min)	Max. Speed (Knots)	Wind (Knots)	Waves (Ft)
Deployment of FTB over a ramp	4	10.0	---	---	---
Retrieval of FTB over a ramp	4	13.0	---	---	---
Loading the FTB with 900 ft of mixed boom	7	9.9	---	Neg	Neg
Maximum speed of the FTB carrying a load of 4350 lb when					
(i) under own power	---	---	16.0	Neg	Neg
(ii) pulled by a UTB	---	---	6.6	Neg	Neg
Maximum speed of the FTB carrying a load of 2600 lb when					
(i) under own power	---	---	17.6	Neg	1.0
(ii) pulled by a UTB	---	---	6.6	Neg	1.0
Maximum speed of the FTB carrying a load of 800 lb when					
(i) under own power	---	---	21.7	Neg	Neg
(ii) pulled by a UTB	---	---	8.7	8	Neg
Deployment of the 900-ft mixed boom into water when faked					
(i) fore and aft	6	8.83	---	Neg	Neg
(ii) athwartship	6	4.3-6.65	---	Neg	Neg
Retrieval of the 900-ft mixed boom from water, and faked athwartship on the FTB	7	18.0-22.9	---	Neg	Neg
Retrieval of the 900-ft boom from the FTB to the pier	8	9.9-10.8	---	Neg	Neg

RECOMMENDATIONS

Power Assistance Unit

1. The PAU should be used during all boom deployments and retrievals.

2. The foot tire control mechanism should be rewired to require an operator to keep it pressed for tire rotation.

3. The PAU drive mechanism should be modified to allow free tire rotation during boom deployment without the necessity of removing the drive chain.

4. PAUs should be modified to ensure that the boom remains on the tires during deployment and retrieval. The modifications shown in Figures 1-5 were found to be adequate.

5. A chute should be used on all PAUs to protect the boom from damage from pilings and protrusions on the pier. The location of the PAU on the pier or the pilings should ensure that the chute clears all protrusions on the pier's edge.

6. The PAU should be rigidly fixed to the pier and/or pilings to ensure that it does not topple over into the water during use.

7. A flat, nonskid walking surface should be provided around the PAU for operator safety.

8. To minimize the risk of entrapment of the tow line, boom tension line, or other small boom protrusions between the tires, the four-tire assembly should be replaced by a single rubber coated cylinder.

9. The selection of the pier should be such as to minimize abrasion of the boom when it is dragged on the pier during deployment and retrieval, and to permit a UTB to pull the entire length of boom over and in line with the PAU. If the pier is particularly rough, covering the area with a strong plastic sheet would reduce abrasion.

10. If possible, the PAU assembly should be placed on a stable turntable so that it could rotate freely and always face the direction of the boom during deployment and retrieval.

Utility Boat

1. A crane is recommended for UTB deployment and retrieval.

2. Two fenders on both the port and the starboard sides of the UTB should be used to protect the UTB. Alternatively, bumpers recommended in reference 8 should be installed.

3. Speedometers and/or tachometers are not recommended for use on UTBs because they are unnecessary.

4. The deck of the UTBs should be treated to produce a nonskid surface.

5. A standard samson post-guardrail design should be developed and it should be incorporated in all present UTBs and all future UTB procurements.

6. A set of three 6-gal fuel tanks should be provided on each UTB to minimize disruption of the oil removal operation due to shortage to fuel.

7. A reel should be attached to the samson post to facilitate paying, retrieval, and storage of the towing line. Alternatively, the line should be stored in a coil form or a figure eight configuration to prevent entanglement.

8. A roller should be provided in the fairlead, if used, to minimize the wear of the tow line at the point of contact.

9. The engines should not be run continuously at full throttle.

10. Towing lengths greater than 50 ft are not required under calm weather conditions.

11. The UTB could be used to tow a towable oil storage bag, to connect and disconnect boom sections, to tow a FTB, and to deploy the small mooring system.

12. The Navy should consider rewriting the specification for larger, more stable, and more powerful UTBs to permit their safe use under adverse weather conditions.

13. The Navy should consider UTB engines with closed cooling systems to ensure trouble-free operation in harbor oil spill removal operations. Because closed cooling system engines are larger in size, it is anticipated that the UTBs will also have to be larger in size.

14. All towing lines should be made from 100 percent polypropylene to ensure that they float on water, and thereby reduce the effort required in pulling them up during the deployment and retrieval procedures.

Flattop Boat

1. The hinges holding the control panel should be redesigned to improve strength.

2. The present swing-open control panel should be changed to a quick-disconnect electrical fitting and the panel should be rigidly bolted to the deck during use.

3. The plywood panels on the rails should be replaced by a fence-type barrier. If panels are considered important, their border strips should be more firmly attached.

4. All hasp latches on the FTB deck should be replaced by lock and handle combinations which are flush with the deck.

5. Antiskid treatment of the deck of the FTB should be provided for safe operation.

6. The port and the starboard sides of the FTB should be protected with rubber bumpers, per recommendations of reference 8.

7. For safety of the crew, a locking mechanism should be installed on each roller to prevent it from turning when a crew member stands on it inadvertently.

8. The location of the rollers should be redesigned so that they are recessed within the overall frame of the FTB.

9. All cleats should be flush with the deck, in a recess, to minimize risk of damage to the FTB during folding and unfolding.

10. Deployment or retrieval of the FTB using a crane is not recommended.

11. The deployment and retrieval of the folding FTB should be carried out over a ramp. If a ramp is not available at a Navy base, then it is recommended that rigid FTBs be procured instead of the folding FTB.

12. The railing supports on the deck should be closer together, and the vertical railing members should be heavier and fastened to the deck with two side flanges instead of deck flanges.

13. The deck folding "strap hinges" should be replaced by "T-butt" hinges, or other stronger hinges.

14. To minimize the risk of damage to the FTB, folding, unfolding, deployment, and retrieval procedures given in Appendix C must be strictly observed.

15. No design changes should be carried out on this folding FTB without prior consultation with the manufacturer.

16. The specifications of the FTB and the Navy boom should be coordinated so that the usable width of the FTB (or the usable length if fore and aft faking is planned in future FTB design) will be slightly in excess of an integral number of the length of the boom float at which the boom could be easily folded without damage.

17. The FTB may be used for:

- transporting people, boom, and equipment between pier and spill site,
- towing a towable storage bag,
- deploying and retrieving boom mooring systems,
- connecting and disconnecting sections of boom, and,
- deployment and retrieval of boom.

18. When not in use, the folding FTB should be stored on land.

Mooring Systems

1. The length of the mooring line connecting the boom to the buoy need not exceed 10 to 15 feet to minimize drift of the boom under winds, waves, and current conditions.

2. The location of the anchor should be determined from the desired location of the boom and the length of the mooring line.

3. The deployment of the boom and the mooring systems should be carried out simultaneously so that the boom can be secured during deployment, particularly in bad weather conditions, to prevent boom drifts due to winds and currents.

4. All boom connectors should have sized holes at the bottom end for appropriate size eyebolts. The eyebolts, which may be attached to all connectors prior to boom deployment or to selected connectors only during mooring, should match the shackles suitable for the selected mooring system.

5. All lines should be faked into a figure eight configuration during storage to minimize twists and risk of entanglement.

6. Bulkhead attachments should be prepositioned at all piers where oil spills are expected to occur. The selection of pilings for bulkhead attachments should be carried out carefully to ensure that the selected locations will not leave spaces through which oil could escape due to currents, winds or waves.

7. The end connector of the boom should match the bulkhead attachment for proper coupling.

8. Several different adaptors and boom connectors should be stored at the base to cater to all possible eventualities.

9. Mooring lines connecting the boom to the buoy should be made from 100 percent polypropylene to ensure that they float on water and thereby reduce the effort required in pulling them up during the deployment and retrieval procedures.

10. The mooring system design should take into consideration the soil type of the harbor seafloor. The holding power of an anchor in clay or silty seafloor is between one-third to one-seventh its holding power in a sandy seafloor.

11. A mooring system with an 80-lb anchor was found to be the heaviest two men could deploy and retrieve without a winch. This system may be used to hold about 8,400-lb in a sandy seafloor, and about 1,200-lb in a clay or silty seafloor.

12. Under current and wind conditions which may produce forces greater than the holding capacity of the 80-lb anchor, heavier mooring systems requiring the use of mechanical equipment during deployment and retrieval, or multiple anchors in tandem should be considered.

Sorbent Distribution System

1. The boot assembly investigated in this test and evaluation should be reduced in length and then tested for performance.

2. More flexible boot materials should be investigated.

3. Larger size EKOPERL sorbent particles should be investigated to minimize the hazard to operators.

4. Unless and until a satisfactory and an acceptable way is found to reduce the dust level, all operators should be required to wear breathing masks and protective glasses during use of the sorbent distribution system. This is felt to be necessary to prevent possible damage to the breathing passages or the lungs of the operators.

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1. CEL ltr L60P/AW/lh, Serial 2164, of 5 Dec. 74.

2. NAVFAC ltr 1043C/JSP of 7 Jan. 75.

3. CEL ltr L60P/SCG/lh, Serial 109, of 21 Jan. 75.

4. CEL ltr L60P/AW/mae, Serial 828, of 14 May 75.

5. CEL ltr L60P/AW/mm, Serial 1954, of 14 Nov. 75.

6. CEL ltr L63/SCG/jlm, Serial 2145, of 24 Dec. 75.

7. NAVFAC ltr 1043C/PCH of 25 Nov. 75.

8. Naval Weapons Engineering Support Activity, Washington Navy Yard. Test and Evaluation of Navy Oil Spill Equipment, by Environmental Engineering Branch, Report No. 2-76, February 1976.

9. Civil Engineering Laboratory. Development of Harbor Oil Spill Removal/Recovery Systems, Phase I, by A. Widawsky, Technical Note N-1372, Port Hueneme, California, January 1975.

10. Naval Facilities Engineering Command. Design Manual: Harbor and Coastal Facilities, Design Manual DM-26, July 1968, P. 26-6-48.

11. Naval Civil Engineering Laboratory. New and Modified Anchors for Moorings, by R. C. Towne and J. V. Stalcup, Technical Report R-044, Port Hueneme, California, March 1960.

12. Naval Civil Engineering Laboratory. Test of Anchors for Moorings and Ground Tackle Design, by R. C. Towne, Technical Memorandum M-066, June 1953, revised September 1957.

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14. Office of the Chief of Naval Operations. Letter OP-987T6/brpjr, Serial No. 2P987: Advanced Development Objective No. 41-21X, Harbor Oil Spill Removal/Recovery Systems, Washington D. C., 6 March 1972.

15. Civil Engineering Laboratory. Standardized Hardware for Oil Spill Containment Booms, by F. J. Campbell, Technical Note N-1343, Port Hueneme, California, June 1974.

Figure 1. Boom retaining modifications for the PAU.

Figure 2. Boom retaining and protective modifications for the PAU.

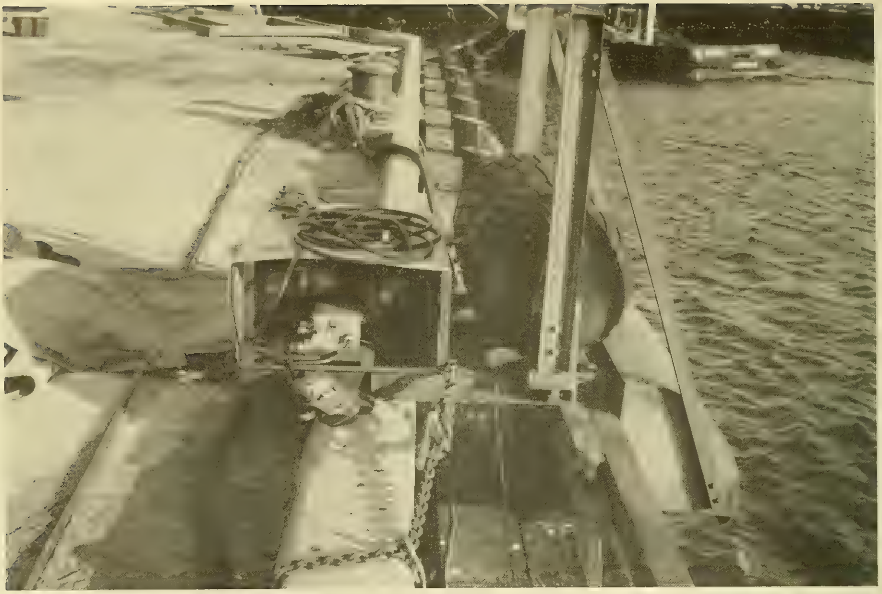

Figure 3. Deployment of the PAU on a pier as seen from the pier.

Figure 4. Deployment of the PAU on a pier as seen from the water surface.

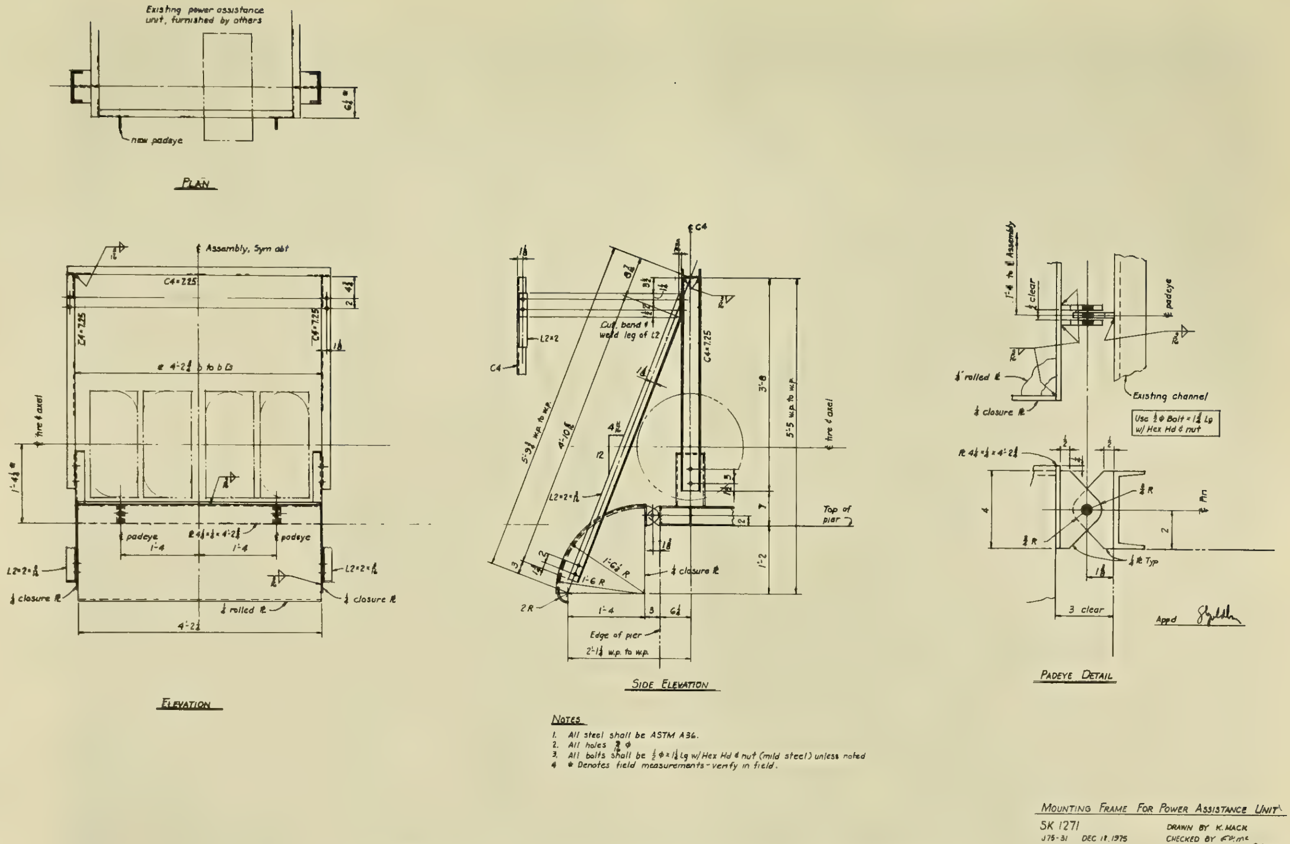

Figure 5. Modifications of the PAU to protect the boom during depolyment and retrieval.

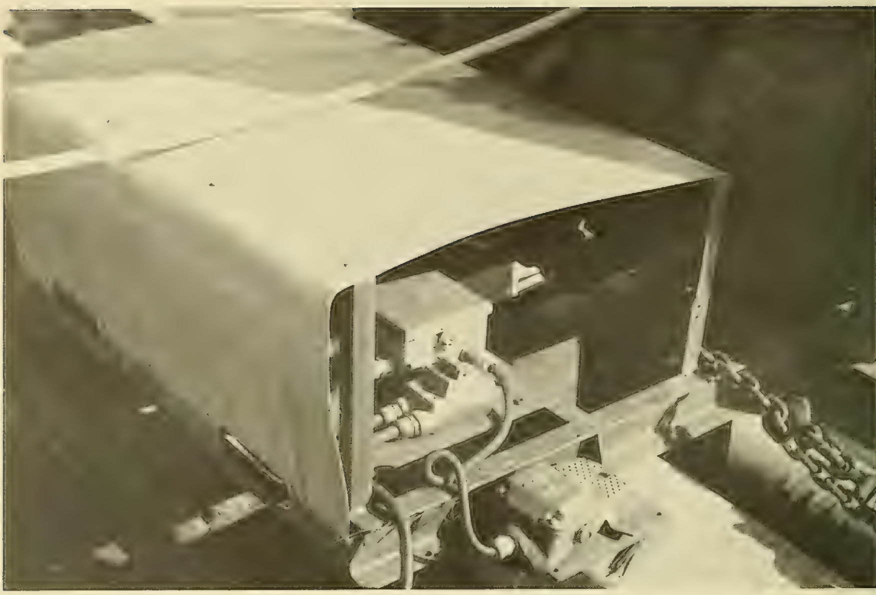

Figure 6. Emergency foot control of the PAU.

Figure 7. Boom faked on pier prior to deployment.

Figure 8. Deployment of boom from the pier.

Figure 9. Samson post modification of the UTB.

Figure 10. Fairlead attachment on the samson post of the UTB.

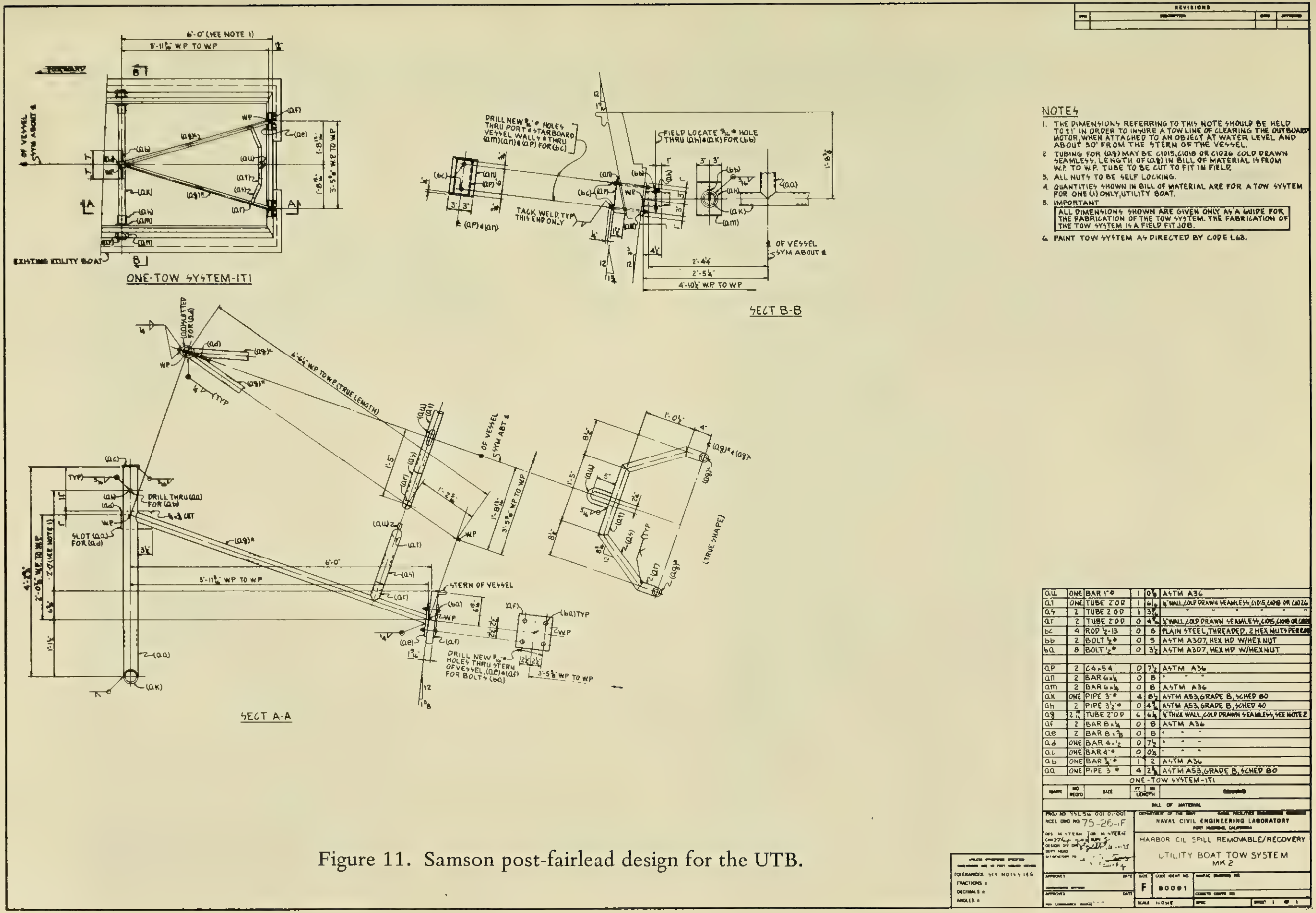

Figure 11. Samson post-fairlead design for the UTB.

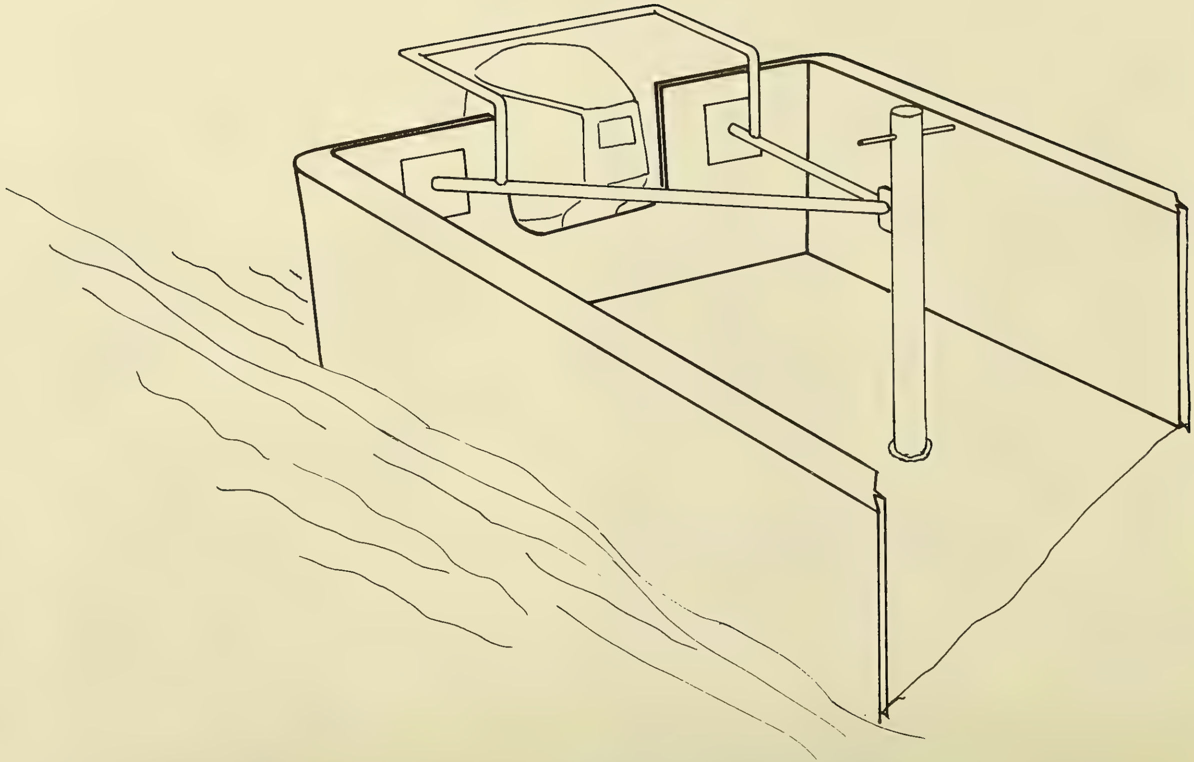

Figure 12. Conceptual illustration of the towing attachment modifications of the UTB.

Figure 13. Deployment of the FTB over a deployment ramp.

Figure 14. Deployment of the FTB with the assistance of engines.

Figure 15. FTB fully loaded with boom.

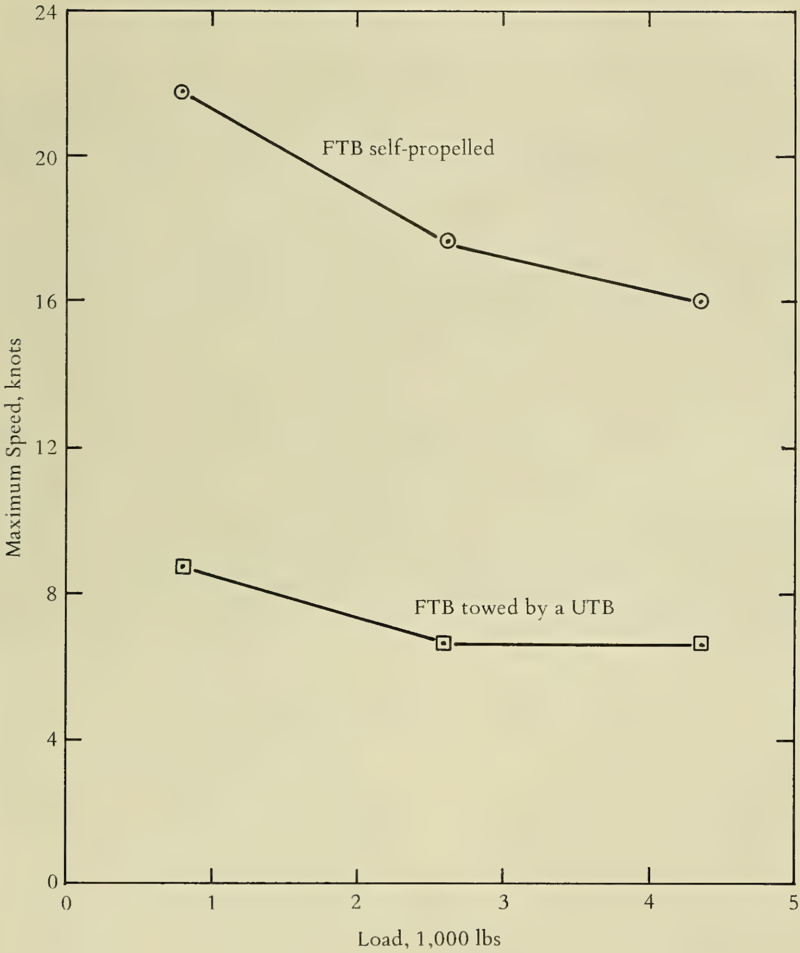

Figure 16. Effect of loading upon the maximum speed of the FTB, both when self-propelled and when towed by a UTB.

Figure 17. Towing of towable storage bag by the FTB.

Figure 18. Hinges holding the FTB control panel.

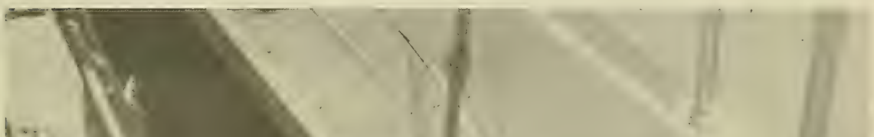

Figure 19. Plywood panels on FTB.

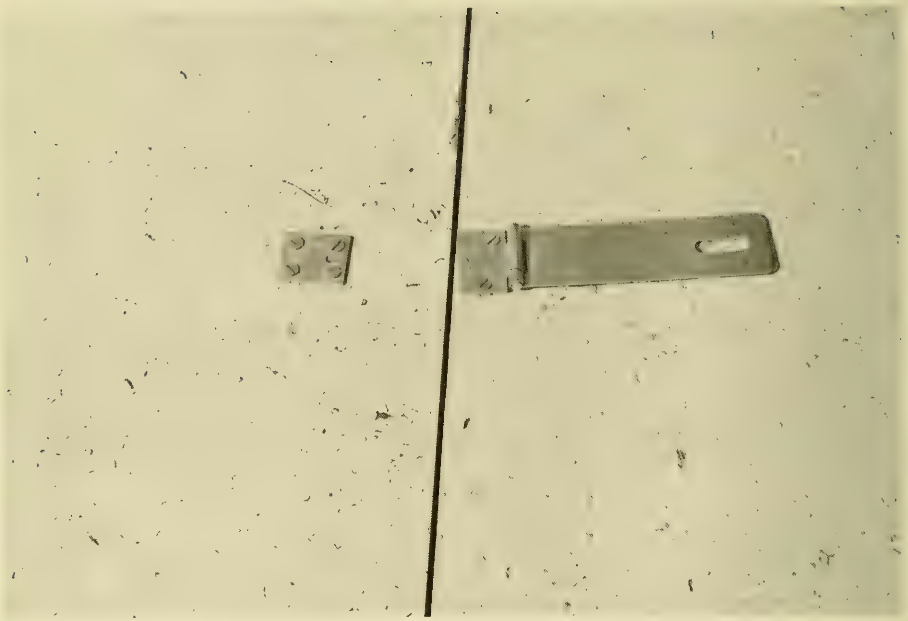

Figure 20. Broken hasp latch on deck of the FTB.

Figure 21. Small, 2,000-lb mooring system.

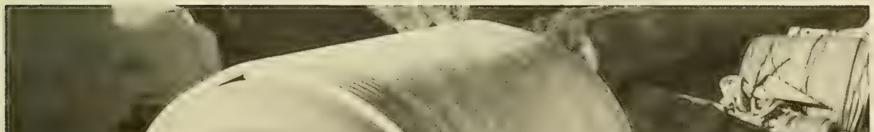

Figure 22. Medium, 5,000-lb mooring system.

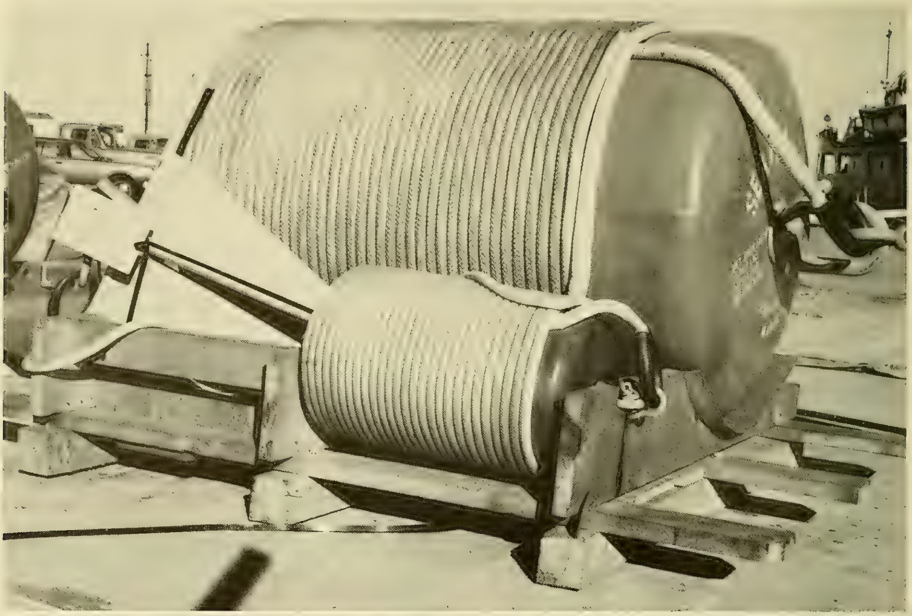

Figure 23. Large, 10,000-lb mooring system.

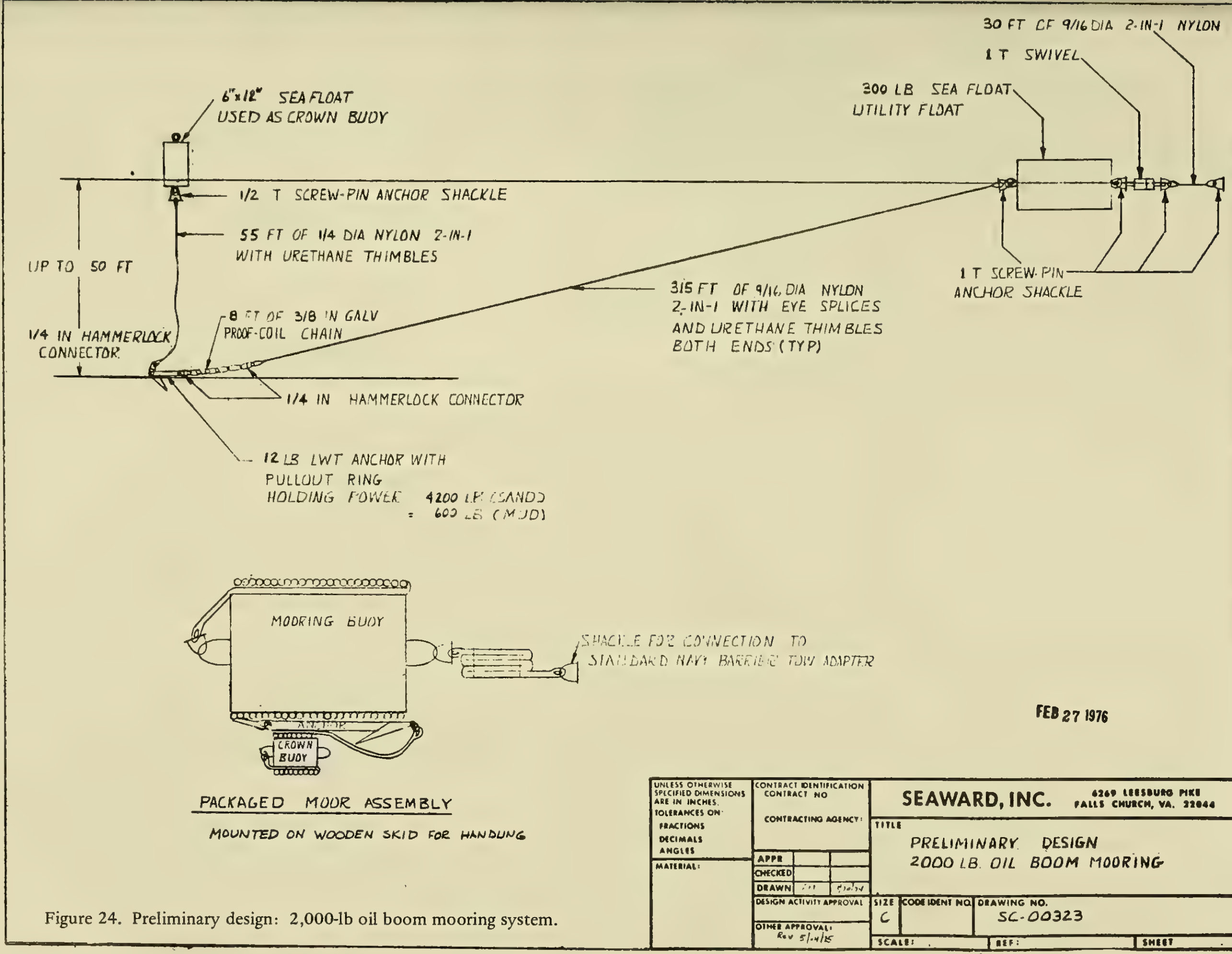

Figure 24. Preliminary design: 2,000-lb oil boom mooring system.

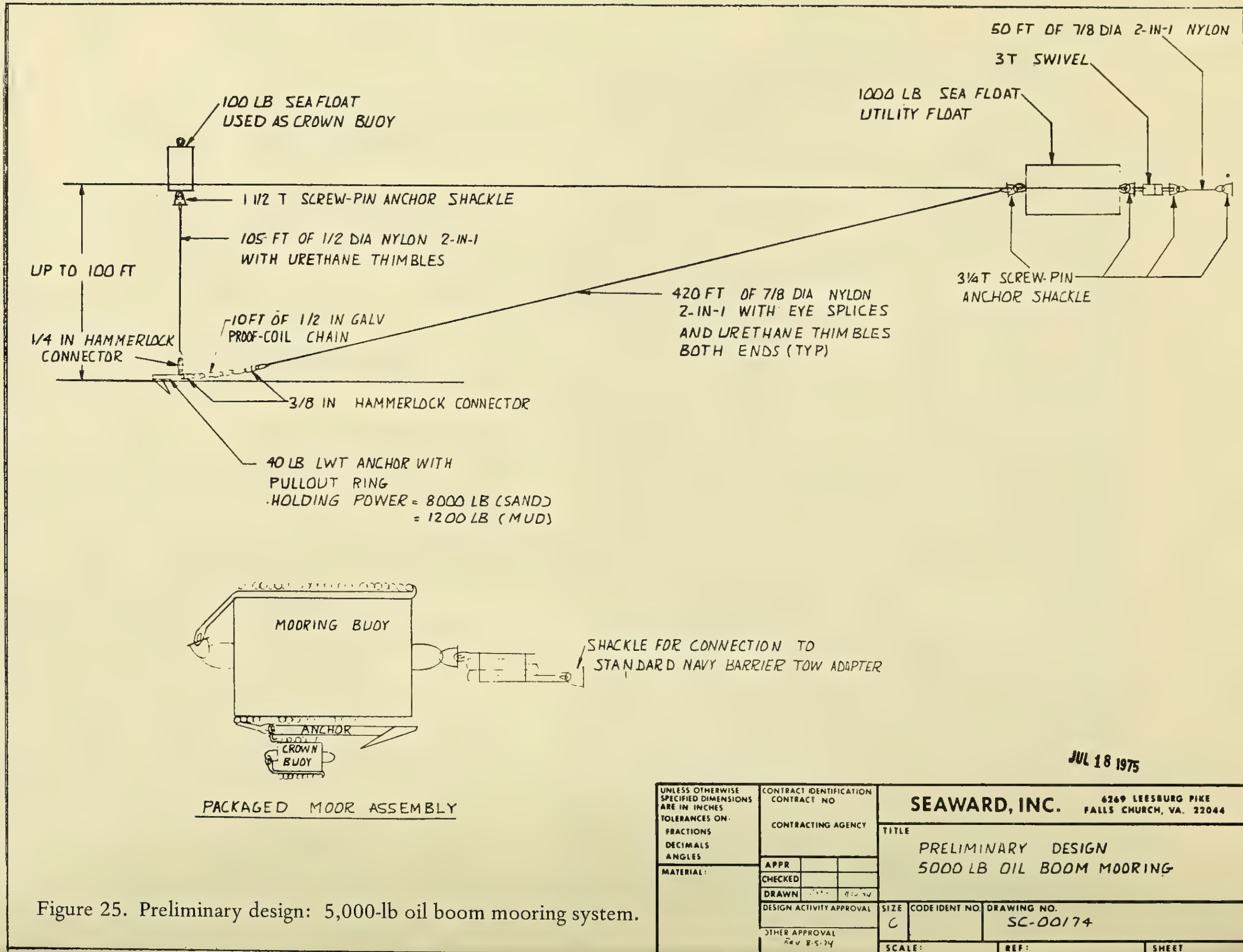

Figure 25. Preliminary design: 5,000-lb oil boom mooring system.

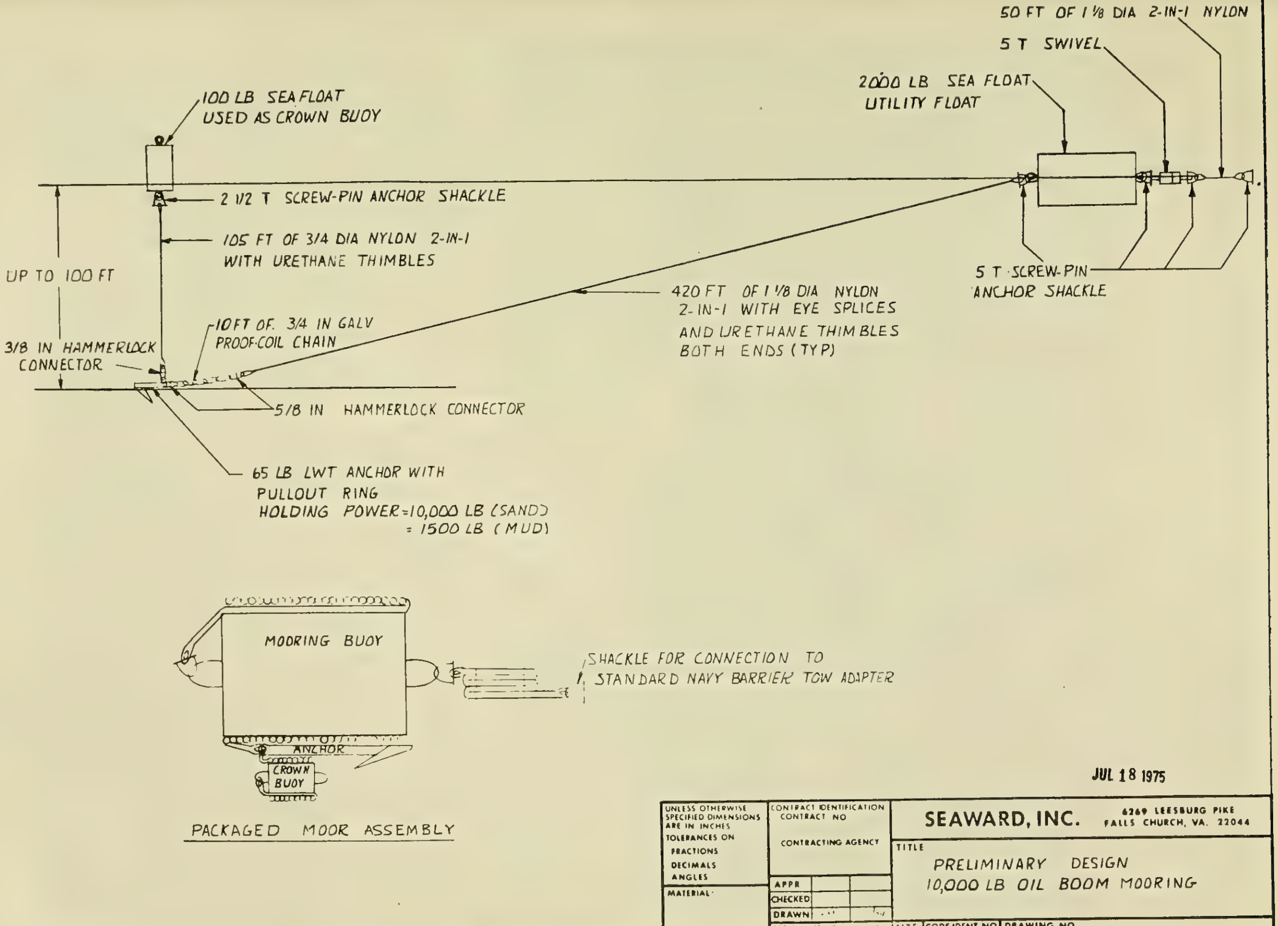

Figure 26. Preliminary design: 10,000-lb oil boom mooring system.

Figure 27. Deployment of mooring systems using the FTB.

Figure 28. Boom encircling a ship.

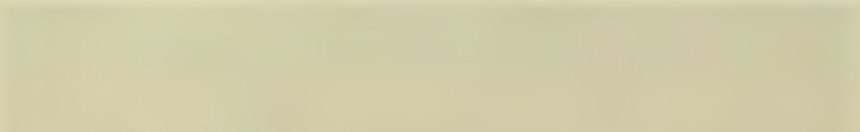

Figure 29. Boom deployed in a circular configuration in an open harbor area.

Figure 30. Attaching a dynamometer to a Caterpillar tractor for the drag test on anchors.

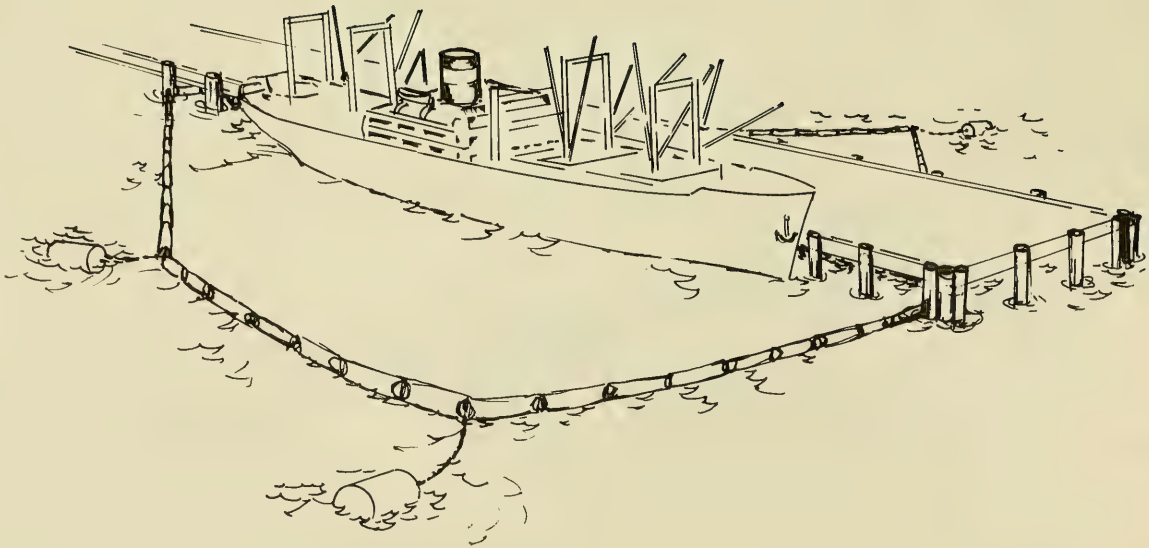

Figure 31. Mooring requirements for boom at an open pier – large ships.

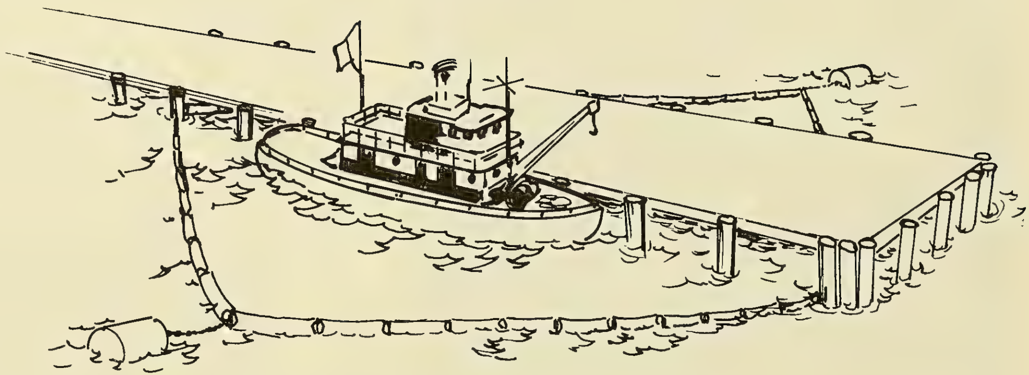

Figure 32. Mooring requirements for boom at an open pier – small ships.

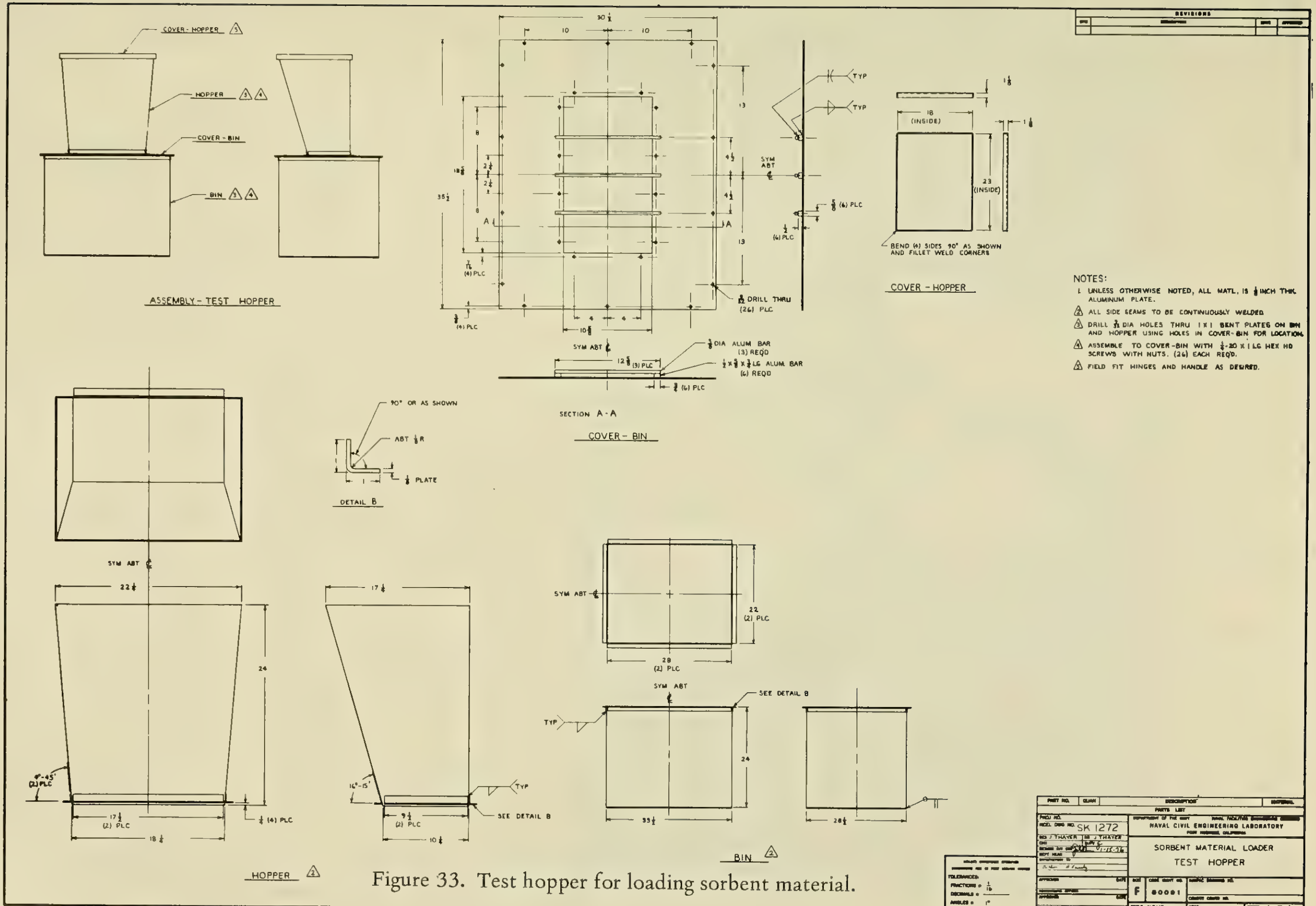

Figure 33. Test hopper for loading sorbent material.

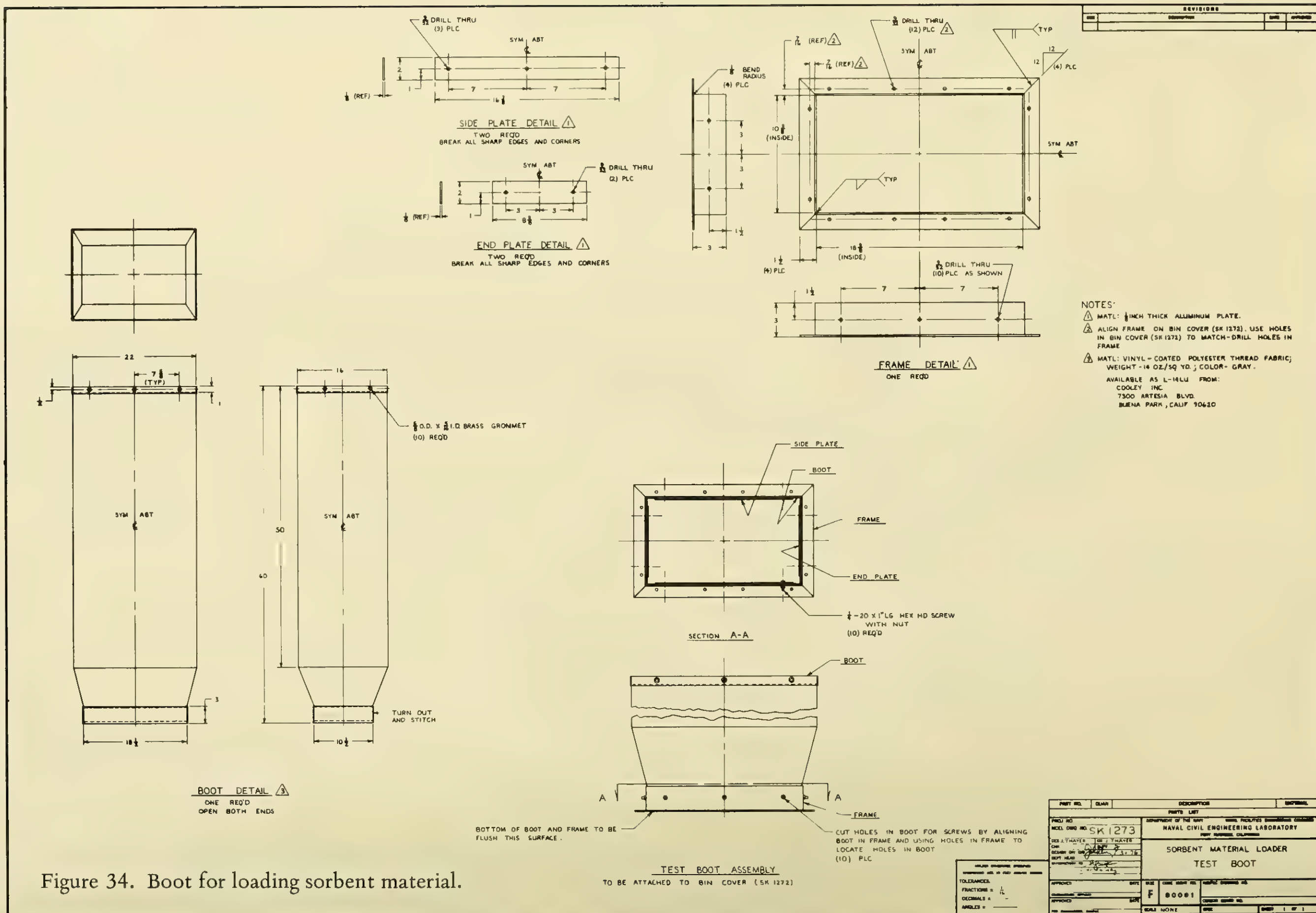

Figure 34. Boot for loading sorbent material.

Figure 35. Test of the bin for the sorbent dispensing system.

Figure 36. The hopper-bin combination of the sorbent dispensing system.

Figure 37. The boot modification of the sorbent dispensing system.

APPENDIX A

DETAILED WORK BREAKDOWN STRUCTURE

FOR EVALUATION OF UTILITY EQUIPMENT

Background

NAVFAC has requested CEL to update the NAVFAC developed purchase descriptions and specifications of the utility and the flattop boats, and then use the updated documents to purchase two utility boats and a flattop boat. NAVFAC will ship a 2,000-lb mooring system to CEL. NAVFAC has also requested CEL to conduct a technical evaluation of the utility boats, the flattop boat, the mooring systems, and the sorbent distribution system. To permit this evaluation, the following 36-inch booms purchased earlier by CEL will be used: 300 ft of Bennett boom (old design), 300 ft of Bennett boom (new design), and 300 ft of Kepner boom. The technical evaluation will be conducted in Port Hueneme harbor as a CEL in-house project.

The evaluation is to be carried out in two phases. Phase I will consist of evaluating all the equipments, analysis of data, and preparation of sketches of all the recommended modifications and changes and preparation of purchase descriptions of additional equipment required to minimize system deficiencies and to improve performance. The development of recommendations will be preceded by a survey of equipment manufacturers and users to determine what is available in areas requiring improvements. Phase II will consist of selection of alternative methods of carrying out the functions found to be inadequately carried our during Phase I, construction and/or purchase of alternative equipment, test and evaluation, and preparation of the final report. The estimates of time and cost required to conduct Phase II will depend entirely upon the findings of Phase I, therefore, no attempt will be made at this time to prepare these estimates.

Objectives

The objectives of this element are to ensure that the technical evaluation proceeds on schedule within the allocated budget, and to keep NAVFAC informed on the progress of the evaluation.

Scope of Work

a. Prepare the test plan and schedule for Phase I.

b. Make the necessary arrangements with the Construction Battalion Center.

c. Maintain a record of the funds and manpower expended.

d. Supervise evaluation tests.

e. Arrange for photographic coverage of the evaluation tests.

f. Provide monthly progress reports to NAVFAC, and other reports as requested.

g. Develop Phase II scope of work with schedule, WBS, and cost estimate.

WBS 2 Procurement of Boats

Background

The NAVFAC procured utility boats and a flattop boat were damaged by a storm when these boats were being used in Boston Harbor. To permit the evaluation of utility equipment, therefore, it is necessary for CEL to purchase two utility and one flattop boats. These procurements will be based upon updated procurement documents and specifications prepared originally by NAVFAC.

Objectives

Purchase two utility boats and one flattop boat and all accessories.

Scope of Work

a. Update NAVFAC procurement documents and specifications for the utility and flattop boats.

b. Complete procurement through standard procedures.

c. Complete check out of both utility boats, the flattop boat, and the accessories to ensure conformance to specifications.

WBS 3 Evaluate Utility Boat

Background

An easily maneuvered utility boat is an important piece of equipment in an oil spill containment and cleanup operation.

Such boats are particularly important when oil containment boom is used in the cleanup operation. They are used to deploy the boom and maintain it in the proper deployment attitude. The boats are also used to conduct spill surveillance, ferry equipment and personnel, and to provide in-water mobility.

Objective

The objective of this element is to evaluate quantitatively the following characteristics of the utility boat: (1) capability to tow boom, (2) capability to tow flattop boat, (3) adequacy of power and propeller, (4) number of personnel required, and (5) feasibility as platform for connecting and disconnecting boom and for deploying and retrieving the boom mooring system.

Scope of Work

a. Determine the maximum speed at which the utility boat can tow 900 ft of 36-inch boom in a straight line.

b. Determine the maximum speed at which two utility boats can tow 900 ft of 36-inch boom in a catenary configuration.

c. Determine the maximum speeds at which the utility boat can tow the flattop boat when the flattop boat is unloaded, partially loaded, and fully loaded with boom.

d. On the basis of items a, b, and c, above, determine whether the power of the utility boat is adequate for maneuvering and for towing boom and the flattop boat.

e. Determine the safe minimum number of personnel required to operate the utility boat.

f. Determine the ease with which sections of boom can be connected and disconnected in the water.

g. Determine whether the utility boat is adequate to deploy and retrieve the boom mooring system.

WBS 4 Evaluate Flattop Boat

Background

Flattop boats used in harbor oil spill recovery operations should be light-weight, easily maneuverable, and have a low freeboard to facilitate work close to the water. They can be used to haul boom to a spill site, to store boom, and to carry any required auxiliary equipment. Flattop boats can also be used as a work area from which to operate some of the recovery equipment, i.e. deploy and retrieve sorbents.

Objective

The objective of this element is to evaluate the following characteristics of the utility boat: (1) structural integrity, (2) stability and buoyancy of various weight distributions, (3) capacity for storing boom and oil recovery equipment, (4) adequacy of engines, (5) maneuverability and ease of handling in water, (6) ease of handling and transporting on land, (7) feasibility of deploying and retrieving boom, and (8) storage method (in water or on land).

Scope of Work

a. Determine whether the means of attaching the working surface of the flattop boat to the pontoons is structurally adequate.

b. Determine whether the strength of the working surface of the flattop is adequate and whether the working surface is sufficiently dent resistant.

c. Determine whether the flattop boat is sufficiently stable and buoyant under various weight loadings with boom.

d. Determine how many feet of 36-inch boom can be stored on the flattop boat, up to a maximum of 1000 ft.

e. Determine the minimum turning radius, the maximum speed, and ease of handling in water with self-propulsion and when towed with the utility boat. Also determine its maneuverability when towed by a utility boat.

f. Determine handling methods on land and transportation requirements on land.

g. Determine personnel and equipment requirements to deploy and retrieve boom using the flattop boat.

h. Determine the best method of storing the flattop boat, i.e. on land or on water. Determine protective equipment required. If stored on water, determine the mooring method.

i. Determine other recommended uses of the flattop (including attachments and ancillary equipment).

WBS 5 Evaluate Sorbent Distribution System

Background

For small oil spills, e.g. less than five gallons, for final polishing, or for marking the boundary of a slick, a sorbent system may be the most effective method. In this method, sorbents are distributed onto the water. After the sorbents have absorbed the oil, they are retrieved by one of the three skimmer systems now being procured by NAVFAC. Some sorbents may be reused after the oil has been squeezed out of them.

Objective

The objective of this element is to evaluate methods to minimize the sorbent dust during operation of the sorbent distribution system.

Scope of Work

a. Modify the hopper of the sorbent distribution system evaluated by NAVWESA to minimize dust generated during filling the hopper with the sorbent.

b. Complete laboratory test and evaluation of the sorbent distribution system with and without the modifications to determine differences in the sorbent dust generated during pouring the sorbent into the hopper under wind conditions.

WBS 6 Evaluate Mooring System

Background

The mooring system is designed for mooring oil containment boom and other oil spill cleanup equipment. Such a system is usually required when the spill occurs away from shore. The system could moor the boom and work platform, thus freeing the utility boat for uses other than keeping the boom on station, e.g., spreading piston film, spreading sorbent, ferrying personnel and equipment. The mooring system is designed for deployment in 100-ft depth waters while developing a holding capacity equal to that required to moor 1000 ft of boom in adverse weather conditions. The system is designed for easy towing behind the utility boat and for continuous line payout when the anchor is dropped. There are four mooring systems available for evaluation. Two are rated at 2,000 lb, one at 5,000 lb, and one at 10,000 lb.

Objective

The objectives of this element are to: (1) evaluate the following characteristics of the mooring system: compatibility with 36-inch boom, procedures for deploying and retrieving system, and personnel requirements; and (2) to determine the best size mooring system for the intended use.

Scope of Work

a. Determine whether the mooring system is compatible with 36-inch boom.

b. Describe the best method of attaching the mooring system to the boom connectors.

c. Determine whether a special coupling is required to attach the mooring system to the boom connectors.

d. Determine whether a bridle assembly is required to stabilize the boom.

e. Determine the number of personnel required to deploy and retrieve the mooring system.

f. Measure the maximum force which the utility boat can exert against the mooring system.

g. Determine the best size of the mooring system for 1000 ft of 36-inch boom. Define anchor size, line size, buoy size, and all other appropriate hardware.

h. Determine whether the rope could be wrapped around the buoy during storage, to prevent entanglement.

i. Determine mooring requirements while encircling a ship with boom to prevent oil spill from spreading.

WBS 7 Evaluate Coupling and Other Ancillary Equipment

Background

The effective use of various support equipment in harbor oil spill cleanup is dependent upon successful operation of various couplings and ancillary equipment in the system.

Objectives

The objective of this element is to test and evaluate various system couplings and ancillary equipment.

Scope of Work

a. Determine suitable methods of attachment of the flattop boat to the utility boat.

b. Determine a suitable ramp and restraining device for boom deployment and retrieval from piers.

c. Determine whether a suitable connection between boom and utility boat other than a bridle system, would be feasible.

d. Determine a suitable method of fastening the buoy to the boom.

WBS 8 Provide Photographic Coverage

Background

In addition to numerical data and descriptive material, the final report will also include photographs of the evaluation tests. In addition, a motion picture film of the tests will be made.

Objective

The objective of this element is to provide photographic coverage of the evaluation tests.

Scope of Work

a. Take color slides of the evaluation tests.

b. Take color, 16-mm motion picture films of the evaluation tests.

c. Submit the slides and film to the Project Manager.

WBS 9 Prepare Final Report

Background

After the technical evaluation of the utility equipment has been completed, a final report will be prepared including measured data, descriptions of the tests, discussion of the test results, conclusions and recommendations, and photographic coverage.

Objective

The objective of this element is to prepare a report covering all the findings of the technical evaluation of the utility equipment.

Scope of Work

a. Reduce all data.

b. Assemble photographic coverage.

c. Prepare a report covering all the findings of the technical evaluation, including recommended procedures on deployment, use, and retrieval of all items of equipment.

d. Submit the report to NAVFAC.

e. File the motion picture films of the evaluation tests for subsequent inclusion in the Phase III film of the Harbor Oil Spill Removal/ Recovery Systems program.

APPENDIX B

PURCHASE DESCRIPTION FOR

20-FT UTILITY BOAT

DATE: 26 FEBRUARY 1975

PURCHASE DESCRIPTION

1. GENERAL

1.1 This purchase description covers requirements for a 20-ft fiberglass reinforced plastic utility boat with an 85 HP outboard engine, trailer, and all the necessary accessories required for use in placing oil spill barrier at an oil spill site. The boat hull shall be of the "Multiple Vee" bottom type with chine, without decks, and shall be a McKee Craft 20-foot "Utility Boat", (McKee Craft 20-ft Utility Boat Brochure, P. O. Box 207, Fairmont, NC) or equal with salient features specified herein. The engine shall be a two-cycle, long shaft, electric starting, outboard and shall be a Mercury Marine model Merc 850 (1074 Mercury Marine Brochure, Fond du Lac, Wisconsin) with salient features specified herein.

2. DESCRIPTION OF BOAT

2.1 It is intended that a stock model boat, which is currently in production, shall be procured. The boat shall be constructed of fiberglass reinforced polyester resin, having an inner shell and an outer shell with buoyancy material between the two shells. The hull shall have no structural members constructed of wooden material. The boat shall have a transom compatible with a long shaft outboard engine. When equipped with an outboard mounting well, the well shall have provisions for self bailing. The boat shall have a fitting for drainage of accumulated water, either on land or when cruising. The boat shall be OBC rated for an engine capacity of no less than 150 HP. Construction shall be strong and durable, suitable for salt water use, and shall conform to recognized commercial standards. The boat shall have good seakeeping qualities for a boat of this size at speeds up to 40 knots.

2.2 OVERALL SPECIFICATIONS, BOAT

Length	19 1/2 - 20 1/2 ft.
Beam	6 1/2 - 7 1/2 ft.
Freeboard with 1500 lb load	
Amid Ship	16 inch min.
At bow	19 inch min.
Transom height	Suitable for long shaft outboard engine
Weight	Not to exceed 1800 lb
Color (exterior & interior)	Light grey Impregnated gel coat

2.3 HULL BUOYANCE MATERIAL

Buoyance material shall be of rigid polyurethane foam in sufficient quantity to support the flooded boat plus one battery weighing 40 lb, one outboard engine weighing 300 lb and six persons weighing 1,000 lb. The buoyancy material shall be foamed in place.

2.4 INTERIOR CONFIGURATION

The boat interior shall have the following floor plan configuration.

2.4.1 The steering/engine control console shall be positioned 1/3 the length of the boat behind the bow and located adjacent to the starboard rail. The console shall be constructed of fiberglass reinforced plastic similar to the hull material. The console size shall allow at least 1/2 the beam width of the boat for passageway between bow and stern. The console shall be equipped with a bevel cornered 18 inch high, rigid, plexiglass windscreen of console width.

2.4.2 One swivel type contoured, cast marine aluminum pedestal seat, made of fiberglass reinforced plastic shall be positioned and bolted in place, centered astern of the console. The bucket seat shall be cushioned and covered with waterproof material and shall have no arms. The seat is to be positioned so as to allow operator to both stand and sit behind the steering wheel.

2.4.3 The stern section shall be left undecked so as to allow ventilation of and access to portable type engine fuel tanks, electrical connections and battery box.

2.4.4 Marine approved side railing about 4" high and bow railing about 12" high shall be installed around three sides of the periphery of the boat.

2.4.5 Floor of interior shall be equipped with a non-skid surface.

2.4.6 Three 6-gal portable type, commercially available, outboard engine fuel tanks shall be positioned in place, with a removable type floor harness strap, inside along the transom of the boat. The tanks shall be rigged to feed the engine consecutively, via a flexible fuel line.

2.4.7 A full length form fitted, easily installed cover of vinyl coated nylon shall be furnished with each boat to provide protection during its storage.

2.5 BOAT ACCESSORIES

2.5.1 Metal fittings -- All metal fittings shall be cast from either manganese, bronze, monel, or stainless steel (300 series) and coated so as to retard corrosion and shall conform to recognized marine commercial standards.

2.5.2 Fasteners -- All metal fasteners shall be nickel plated brass or stainless steel (300 series) and coated so as to retard corrosion and shall conform to recognized marine commercial standards.

2.5.3 Registry numbers -- Registry numbers, to be assigned after contract award shall be 3" high black painted numbers on aft face of transom, port side, 3" below the gunwale.

2.6 TOWING ACCESSORIES

2.6.1 The boat shall be equipped with two (2) symmetrically located, transom mounted, 1" I.D. min. towing eyes, fastened so as to be capable of towing loads of 6,000 lb each, without structural damage to the hull.

2.7 MOORING ATTACHMENTS

2.7.1 The boat shall be equipped with at least five (5) mooring cleats, one located in each corner, and one at the prow. A bow eye, used for boat mooring and towing shall be installed on the forward side of the stem.

2.8 HOISTING FITTINGS

2.8.1 The boat shall have three hoisting fittings inside the boat, two of which shall be located at the transom, port and starboard, and one shall be located forward in the stem. Each hoist fitting, and its mounting, shall be rated for load through 2,000 lb.

2.9 U.S. COAST GUARD APPROVED SAFETY EQUIPMENT WITH MOUNTING BRACKETS

2.9.1 The following Coast Guard approved safety equipment with appropriate brackets, mounted along the boat inside walls, shall be furnished with each boat. The equipment shall satisfy subchapter C, CFR, part 24 and 25.

2.9.1.1 2 each - 5-ft long wooden paddles
2.9.1.2 1 each - 8-ft aluminum boat hook
2.9.1.3 1 each - 5-lb dry chemical PKP fire extinguisher
2.9.1.4 1 each - first aid kit
2.9.1.5 1 each - emergency flare kit
2.9.1.6 1 each - 15-lb Danforth anchor
2.9.1.7 1 each - 100-ft length of 1/2-inch nylon mooring line with stainless steel thimble and eye splice at one end.
2.9.1.8 4 each - life preservers, jacket type, fibrous glass filled.
2.9.1.9 4 each - fastened in place rubber foot step pads
2.9.1.10 1 each - compressed air fog horn
2.9.1.11 2 each - vinyl, foam filled, 24" long fenders

2.10 ELECTRICAL ACCESSORIES

2.10.1 The boat shall be furnished with running lights conforming to U.S. Coast Guard regulations and requirements (Subchapter C, 46 CFR, part 24 and 25) for International waters, complete with wiring for 12 volts, D.C., and waterproof switch mounted on the control console. One variable direction, portable, switch operated, 12 volt sealed beam spotlight of not less than 35,000 candle power, shall be installed near the control console. The spotlight shall have a 6 ft stretch cord with waterproof plug connected into a waterproof outlet. A heavy duty marine type battery designed for starting the furnished engine shall be provided in a plastic battery box with cover. The battery box shall be secured to the boat floor with a removable strap in a convenient location in the stern of the boat.

2.11 ENGINE CONTROL ACCESSORIES

The boat control console area shall be furnished with the following installed items:

2.11.1 A single lever control, completely mechanical mechanism, which regulates engine throttling, gear shifting, and also provides a receptacle for the ignition key. The control mechanism shall be equipped with appropriate length control cables and connectors, fastened along the interior side of the boat, to link the mechanism to the furnished outboard engine. Mechanisms having servo-hydraulic assist are not acceptable.

2.11.2 A remote control manually operated choke switch with connections to the engine.

2.11.3 A 15-inch (minimum) diameter steering wheel operating a rack and pinion steering with a push-pull cable to the transom.

The cable shall be fastened along the interior of the boat side. Steering brackets appropriate to the supplied outboard engine shall be furnished to connect the engine to the steering cable.

2.11.4 An appropriate (0-8000 RPM) heavy duty tachometer and connections shall be installed to monitor engine speed and to prevent excessive engine loading.

2.11.5 An appropriate water temperature or water pressure gauge and connections shall be installed to monitor cooling water when the engine is used under heavy loading.

2.11.6 An appropriate ammeter gauge and connections shall be installed to monitor the electrical charging system.

2.11.7 An appropriate engine operating log meter and connections shall be installed which record operation usage time in hours and tenths of hours.

3. DESCRIPTION OF ENGINE

3.1 It is intended that a stock number, Mercury 85 hp, long-shaft, outboard engine with electric starting, which is in production, shall be furnished. The engine shall have a generator or alternator to recharge the furnished battery and power all electrical accessories installed on the boat. Operation and maintenance manuals shall be supplied with the engine. All standard equipment supplied by the manufacturer shall be furnished with the engine. The engine shall be installed with all attachments and connections assembled and functioning.

4. PROPELLER

4.1 The engine shall be delivered installed with an aluminum three (3) bladed propeller, Mercury Marine Part No. C-48-33242A3 or equal and shall be designed to pull loads in excess of six thousand (6,000) lb.

5. DESCRIPTION OF TRAILER

5.1 The utility boat and engine shall be delivered with an appropriate boat trailer having a rated capacity of three thousand pounds. Trailer lighting and electrical systems shall comply with Boating Industry Association (BIA) Recommended Practices. Towing vehicle 2" coupling ball and electrical receptacle and wiring harness shall also be provided to allow the system to be quickly connected to a Navy pick-up truck of opportunity towing vehicle. All structural parts and fasteners of the trailer shall be fabricated of metal having been protected by corrosion retarding processes other than

paint, which are certified as protective in a salt water neighboring environment. Quick release nylon web safety straps for holding boat trailer in transit shall be provided. The trailer shall be designed to be towed at turnpike speeds by any Navy standard procured pick-up truck. The trailer shall have provisions for short distance, manual maneuvering by two men, and horizontal storage, when not connected to a tow vehicle. When stored, fully loaded, the trailer shall be capable of being attached to a trailer hitch equipped pick-up truck, by one man without requiring any manual lifting. The trailer shall be designed to allow the trailer bed to tilt down while remaining hitched to the truck to allow easier on and off loading of the boat in the water. The trailer shall be equipped with an electric, 12 volt D.C. powered winch with steel cable which shall be rated for loads including six thousand (6,000) lb. The winch shall have a manual override which shall be equipped with a hand crank.

APPENDIX C

INSTRUCTIONS FOR

SLICKBAR FOLDING BOAT WITH TRAILER

INSTRUCTIONS FOR FOLDING BOAT WITH TRAILER

NOTE: Read complete instructions thoroughly before proceeding.

1. INITIAL STEPS

1.1 The davit with winch and the stiff leg support are secured on the trailer with two shock cords. Remove these cords.

1.2 Carry the davit and stiff leg to the rear of the boat. Mount the davit into one of the aft boom guides. Attach the stiff leg between the davit and the clevis provided on the opposite boom guide, Figure C-1.

1.3 Remove and set aside temporarily the two turn buckle tie down assemblies, Figure C-2.

1.4 Remove the locking angle sections that secure the engine boxes using a 9/16 wrench. Do not discard the angle sections and fasteners, Figure C-3.

1.5 Using manpower, lift off the engine with box and place on the ground in an upright position with the top hatch up, Figure C-4.

NOTE: If the box seems to have an interference fit when you remove same, use one of the turn buckle assemblies to tighten up on the opposite end tilting the boat to clear hasp and lock assembly.

1.6 Repeat procedure for the remaining box.

1.7 Replace the turn buckle tie down assemblies on both sides temporarily and tighten lightly. Caution: The box with engine is top heavy in upright position.

2. EXTENDING THE WING HULLS

2.1 Place the sling, color coded on one end in red, through the center of the color coded (red) galvanized cleat on the folding hull and loop it around itself, Figure C-5.

2.2 Place the boat snap end on the eye provided on the outside of the hull, Figure C-6.

2.3 Attach the winch cable to the ring and winch the hull up the hull support as far as possible, then push it over center beyond the teetering position, Figures C-7 to C-9.

2.4 Switch the function lever (on winch) to lower position and start lowering away on the winch, <u>making sure the handle is held securely,</u> as no brake lever is provided, Figures C-10 and C-11. Caution: Look out for cable cluster pinching between hulls.

2.5 Continue lowering until the hull is level with the main deck, Figure C-12. Caution: Do not remove the hull sling at this point but leave a slight strain on the cable.

2.6 Fasten the hulls with the hex bolts and nuts provided and, using two flat washers, one each side, tighten securely, Figure C-13.

2.7 Remove the sling and place it through the eye of the galvanized cleat on the other hull and repeat the same procedure. After use, store the sling in one of the hatches.

3. <u>ENGINES</u>

3.1 With the winch still in place, swing open the top of the engine box, swing open the front door, remove the engine cover and set aside.

3.2 Attach the engine sling (to be found in one of engine boxes), and winch up the engine out through the front of the box, Figures C-14 and C-15.

3.3 Attach it to the transom and fasten using the necessary hardware, Figures C-16 and C-17.

3.4 Repeat this procedure for the other engine using the same sequence.

3.5 Attach the throttle and shift controls, the steering controls, battery cables, gas lines, etc. to both engines. Gas tanks should be placed in the outer hulls, batteries remain in the center hull. When this has been accomplished, mount the engine covers and lock in place.

4. <u>DAVIT REMOVAL</u>

4.1 The davit may or may not be left on board while using the boat. To dismantle, remove the toggle bolt from the davit shaft and the davit stiff leg support.

4.2 Remove the bottom toggle bolt on the stiff leg and remove the davit. Store the davit on the ground temporarily.

4.3 Pick up the two hull wing supports and store them in the main deck, forward or center, hatch.

5. BOW BOOM GUIDES

5.1 Insert the bow boom guides in the holes provided in the bow section of the boat.

6. THE CONTROL CONSOLE

6.1 Remove the lock on the console hatch located on the starboard side, aft, and lift the hatch to an open position.

6.2 Grasp the control console and carefully lift it to an upright position, tilt it slightly forward in order to be able to close the console hatch and then tilt the control console back to an upright position, Figure C-18. Lock it with the two locks provided on the deck.

7. SAFETY RAILS

7.1 The inner and outer rails have been marked with the necessary coding as to whether port or starboard. This appears on the outer rails on the bow end. They are marked "front rail starboard" - "front rail port" - "aft rail starboard" or "aft rail port", Figure C-19. The inner rails are the long 30"-high rails. The outer rails are the shorter 42"-high rails.

7.2 Install the inner rails inboard of the craft in the deck flanges provided, making sure that they are firmly in place.

NOTE: When installing the inner rail with the stern light attached, feed through the electrical plug through the deck fitting.

7.3 Using an Allen wrench, secure all the deck flanges with the locking screws provided.

7.4 Install the outer 42" high rails in the deck flanges provided and repeat the previous procedure, finally locking them in place on both sides.

8. HATCH LOCKS

8.1 There are six locks provided with keys which lock all the hatches and all keys are interchangeable.

9. LAUNCHING THE BOAT

9.1 Remove the turn buckle tie downs and put these aside. Back the trailer into the water as far as possible and launch the boat.

9.2 When the boat is launched and the trailer is removed from the water, place the two engine boxes in their respective places on the trailer and secure the davit and stiff leg in their proper places on the trailer. Pick up turn buckle tie down assemblies.

10. THE WORK PLATFORM

10.1 The work platform can be placed on the bow, either port or starboard, and can be retracted by pivoting backwards aft in a stowable position on deck and kept on the boat if desired. If not desired, it can be completely removed by removing the toggle pins that secure it in place, Figures C-20 and C-21.

Caution: When using the work platform, make sure that the foot that contacts the hull is lowered into position before stepping on the platform.

11. RETRIEVING THE BOAT

11.1 Prior to retrieving the boat, remove from the trailer the two engine boxes and davit and stiff leg support and lay these aside.

11.2 Lower the trailer into the water as far as possible.

11.3 Line up the boat with the trailer and run it up on the trailer by the use of the engines as far as it will go.

11.4 Attach the winch line to the towing eye on the center hull, and, by the use of the winch, winch it up approximately 2" away from its full forward position and remove the craft out of the water.

12. FOLDING THE HULLS

12.1 When the trailer is up on shore, mount the two aft turn buckle tie downs and install the davit and stiff leg support.

12.2 Disconnect all engine controls. Remove fuel tanks from the outer hulls. Remove the rails, outer and inner. Collapse the console into the hull. Snap on the locks on the hatches. Lastly, remove the engines.

12.3 Before folding the hulls, you must position the hull supports in their proper locations.

NOTE: There are two supports for the outer hulls. The rear support is placed just forward of the rear hatch main deck section and the forward deck support is placed approximately one foot aft of the bow roller.

12.4 Attach the sling, remove the nuts, bolts and washers that secure the two outer hulls and start folding the hulls.

13. READYING TRAILER FOR TOWING

13.1 The ball diameter for the coupler is 2 5/16". Secure and lock the coupler.

13.2 Attach the safety lines.

13.3 Install the electrical hookup between the vehicle and the trailer.

14. MAINTENANCE

14.1 Maintenance on the trailer should be minimal if after launching the boat and again after retrieving it from the water, it is washed down with fresh water.

14.2 Periodically the bearings should be checked to insure that they have the proper amount of grease.

14.3 Tires should be checked periodically for proper pressure.


Figure C-1.

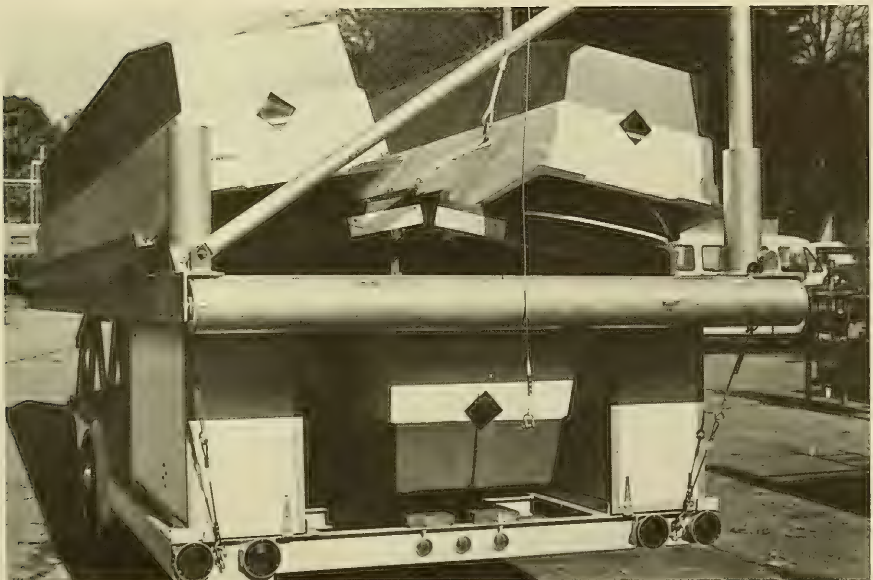
Figure C-2.


Figure C-3.


Figure C-4.

Figure C-5.

Figure C-6.

Figure C-7.

Figure C-8.

Figure C-9.

Figure C-10.

Figure C-11.

Figure C-12.

Figure C-13.

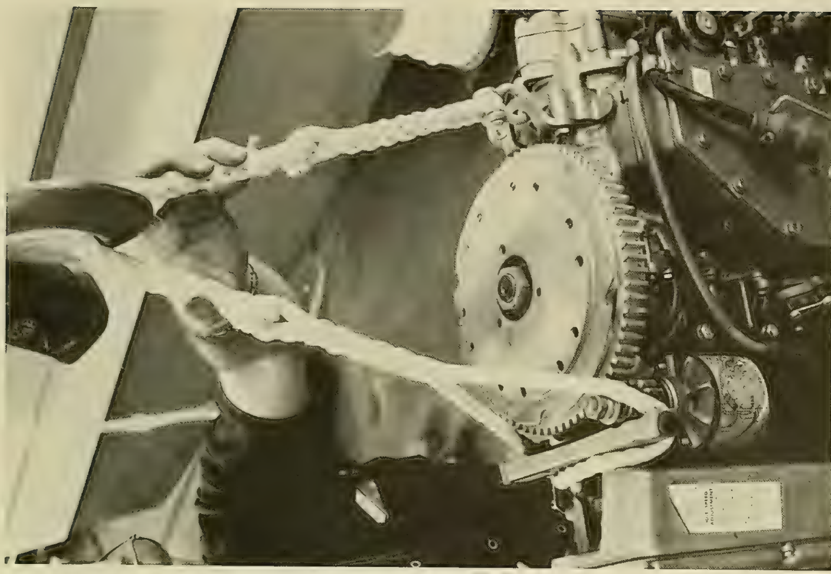

Figure C-14.

Figure C-15.

Figure C-16.

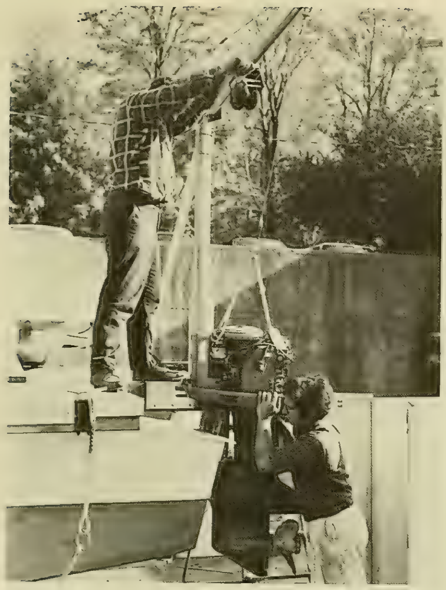

Figure C-17.

Figure C-18.

Figure C-19.

Figure C-20.

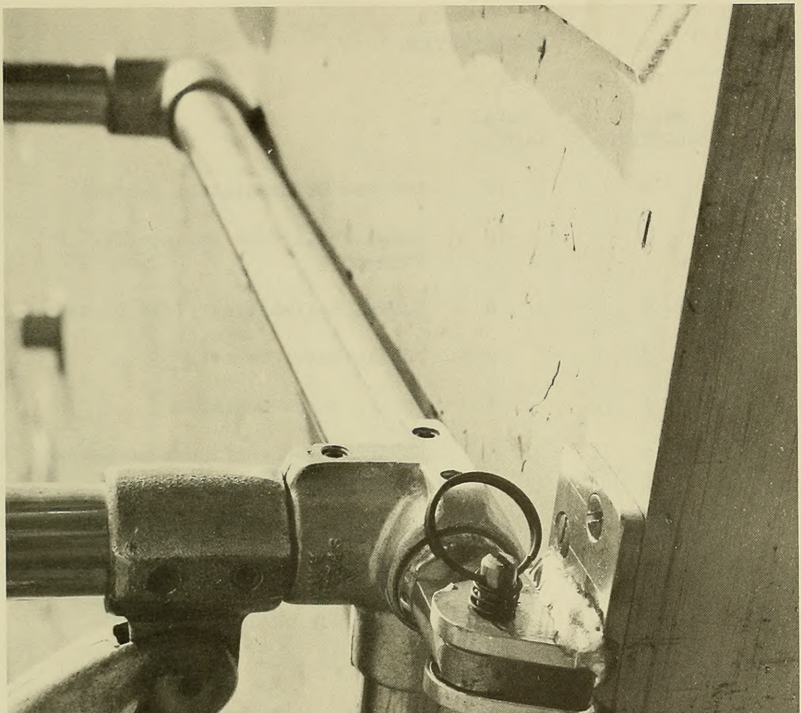

Figure C-21.

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